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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Crop Coefficient for Onion (*Allium Cepa*. L) Under Deficit Irrigation Forsemiarid Tropics of Maharashtra

R.G. Bhagyawant[1], S.D. Gorantiwar[2] and S.D. Dahiwalkar[3]

ABSTRACT: *Crop coefficient values (Kc) were computed as the ratio of reference evapotranspiration (ETr) to actual evapotranspiration (ETo).The study showed that crop water use of the onion crop decreased with increase in irrigation deficit.The estimated values of Kc during the initial, mid-season, and late season were 0.61, 1.31 and 0.73, respectively. Fifth-order polynomials were used to well predict Kcas functions of days after transplanting (DAT) and cumulative growing degree-days (GDD), respectively. The estimated Kcvalues of the present work can be used for irrigation scheduling of onion crop with similar agro-climatic conditions.*

Keywords: *Onion, deficit irrigation, crop coefficient (Kc), yield response factor (Ky), crop water use.*

INTRODUCTION

The total area under onion in the world is about 3.971 million hectares and the production is 75.97 million tones. The total area under onion in India is 1.064 million hectares and the total production is 15.118 million tones. India ranks first in area and second in production among the onion producing countries of the world. India accounts for 26.8 per cent the total area and 19.9 per cent the total production of the world. The knowledge of water requirement of the onion crop under deficit irrigation is necessary as the consequences of deficit irrigation regimes are yet to be fully understood. A key parameter commonly required in determining crop water requirement is the crop coefficient (Kc).Crop coefficient is the ratio of crop actual evapotranspiration (ETc) to a reference evapotranspiration (ETo) which can be calculated using the FAO-Penman-Monteith method (Allen *et al.*, 1998). The crop coefficient for onion crop reported by FAO and other scientists are different for different region.Jianhua Zheng *et al.*, (2012) reported the estimated value of Kc during the initial, mid-season and late season was 0.73, 1.28, and 0.70, respectively, whereas FAO-56 suggested the crop coefficient values during the initial, mid-season and late season was 0.70, 1.05, and 0.75 respectively.

In order to determine the crop coefficient of onion crop for semiarid tropics of Maharashtra the present study were carried out by raising the onion crop under different regimes of deficit irrigation approach.

MATERIALS AND METHODS

The field experiment to determine crop coefficient of the onion *(Allium cepa L.)* cv. N-2-4-1 crop under the deficit irrigation approachwereconducted during *rabi* seasons of 2012 at Instructional Farm of the Department of Irrigation and Drainage Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri. Experimentswere carried out in Randomized Block Design (RBD) with 27 treatments and two replications based on different combinations of the quantity of water stress days (no stress- (0.00S), 20% stress- (0.20S) and 40% stress- (0.40S) during different crop growth stages vegetative Stage (VS) – up to 50 days, bulb development stage (BDS) - 50 to 75 days and bulb enlargement stage (BES) – 75 to 100. The different combinations of thetreatments were:

[1] Associate Professor, Department of Agriculture Engineering, College of Agriculture, Badnapur.
[2] Head, Department of Irrigation and Drainage Engineering, Dr.A.S. CAE, M.P.K.V, Rahuri.
[3] Associate Professor, Department of Irrigation and Drainage Engineering, Dr.A.S. CAE, M.P.K.V, Rahuri

T1 VS-0.00S, BDS-0.00S, BES-0.00S,
T2. VS-0.00S, BDS-0.00S, BES-0.20S,
T3. VS-0.00S, BDS-0.00S, BES-0.40S,
T4. VS-0.00S, BDS-0.20S, BES-0.00S,
T5. VS-0.00S, BDS-0.20S, BES-0.20S,
T6. VS-0.00S, BDS-0.20S, BES-0.40S,
T7. VS-0.00S, BDS-0.40S, BES-0.00S,
T8. VS-0.00S, BDS-0.40S, BES-0.20S,
T9. VS-0.00S, BDS-0.40S, BES-0.40S,
T10. VS-0.20S, BDS-0.00S, BES-0.00S
T11. VS-0.20S, BDS-0.00S, BES-0.20S,
T12. VS-0.20S, BDS-0.00S, BES-0.40S
T13. VS-0.20S, BDS-0.20S, BES-0.00S,
T14. VS-0.20S, BDS-0.20S, BES-0.20S
T15. VS-0.20S, BDS-0.20S, BES-0.40S,
T16. VS-0.20S, BDS-0.40S, BES-0.00S
T17. VS-0.20S, BDS-0.40S, BES-0.20S,
T18. VS-0.20S, BDS-0.40S, BES-0.40S
T19. VS-0.40S, BDS-0.00S, BES-0.00S,
T20. VS-0.40S, BDS-0.00S, BES-0.20S
T21. VS-0.40S, BDS-0.00S, BES-0.40S,
T22. VS-0.40S, BDS-0.20S, BES-0.00S,
T23. VS-0.40S, BDS-0.20S, BES-0.20S,
T24. VS-0.40S, BDS-0.20S, BES-0.40S
T25. VS-0.40S, BDS-0.40S, BES-0.00S,
T26. VS-0.40S, BDS-0.40S, BES-0.20S
T27. VS-0.40S, BDS-0.40S, BES-0.40S

Irrigations were scheduled at every growth stage of onion crop as per stress underlined in each treatment. The stress was estimated from the moisture content stress in the rootzone. The depths of irrigation water were applied according to the treatments.

COMPUTATION OF CROP COEFFICIENTS

Crop water demands are directly connected with crop evapotranspiration and they vary depending on crop growth. The crop coefficient (Kc) values vary according to different crop growth stages. In this study, the Kc values were estimated for *rabi* onion by field water balance method. The crop evapotranspiration values were obtained from the field method by monitoring the soil moisture in the crop root zone and corresponding ETr values were estimated by climatic data. The weekly values of crop coefficients were computed for *rabi* onion as the ratio of weekly crop evapotranspiration and weekly reference evapotranspiration.

The polynomial equation of following orders were fitted with Kc as the dependent variables and (t/T) as the independent variables. These are:

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3 \quad (2)$$

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3 + a_4\left(\frac{t}{T}\right)^4 \quad (3)$$

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3 + a_4\left(\frac{t}{T}\right)^4 + a_5\left(\frac{t}{T}\right)^5 \quad (4)$$

Where,

Kc_t = crop coefficient of t^{th} day.

a_0, a_1, a_2 = constants of equations.

t = day considered.

T = total period of crop growth from sowing to harvesting (days)

Regression coefficients were estimated and tested for its significance to decide upon the validity of the particular equation.

CROP COEFFICIENT (KC)

Crop water demands are directly connected with crop evapotranspiration and they vary depending on crop growth. The crop coefficient (Kc) values vary according to different crop growth stages. The ETr values can be estimated by Penman-Monteith method; however crop coefficients values are generally adopted from FAO. The crop evapotranspiration values ETc were obtained from the field method by monitoring the soil moisture in the crop root zone and corresponding ETr values were estimated by climatic data from Penman-Monteith method. The weekly values of crop coefficients were then computed for *rabi* onion as the ratio of weekly crop evapotranspiration and weekly reference evapotranspiration. The actual evapotranspiration of onion and reference evapotranspiration were determined during study period 2012 and then the crop coefficient values were calculated. Further these

Kc values were represented in the form of polynomial equation, with respect to the ratio of days to total crop period. The actual evapotranspiration, reference evapotranspiration and crop coefficient for *rabi* onion crop during 2012 are shown in Tables 1.

Table 1
Actual evapotranspiration, reference evapotranspiration and crop coefficient (K_c) of onion in 2012

Period, days	*Moisture depleted, mm (ETa)*	*ETr (mm)*	*Kc*
1-5	17.51	27.45	0.637
8-17	15.90	22.01	0.722
20-29	17.68	21.61	0.818
32-42	25.21	30.66	0.822
45-54	35.45	33.26	1.066
57-65	37.12	31.42	1.181
68-75	39.29	34.37	1.143
78-85	39.50	32.09	1.231
88-95	40.14	31.82	1.261
98-106	34.40	32.92	1.045
109-116	30.41	40.66	0.748

The polynomial equations of different orders are presented in Tables 3 for 2012 season. These are shown graphically in Figure 1.

Table 2
Crop coefficient equations of different orders of polynomials for onion for year 2012

Polynomial	*Equation*	R^2	*RMSE*
3rd	$Y = -5.453x^3 + 5.678x^2 - 0.513x + 0.680$	0.945	0.4004
4th	$Y = -7.159x^4 + 8.540x^3 - 3.3252x^2 + 1.152x + 0.559$	0.957	0.3290
5th	$Y = -12.42x^5 + 23.22x^4 - 18.26x^3 + 6.993x^2 - 0.0590x + 0.630$	0.959	0.3124

The determination coefficient (R^2) of 0.945, 0.957 and 0.959 and RMSE of 0.4004, 0.3290 and 0.3124 respectively were observed for the polynomial equations of 3rd, 4th and 5th order respectively as seen from Table 2. It is observed from the table that the best fit regression equation is 5th order polynomial function, which is given by equation (5) for 2012 is recommended for onion.

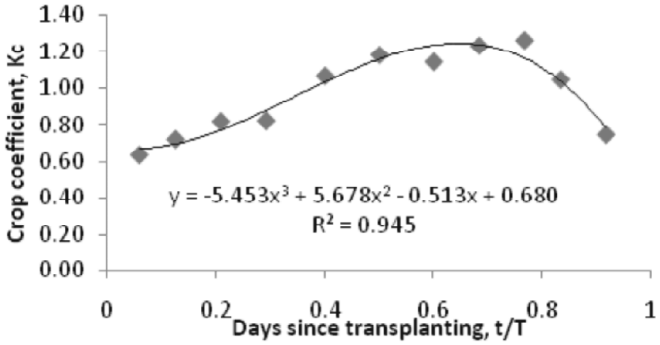
$$K_c = -12.42\left(\frac{t}{T}\right)^5 + 22.22\left(\frac{t}{T}\right)^4 - 18.26\left(\frac{t}{T}\right)^3 + 6.99\left(\frac{t}{T}\right)^2 - 0.059\left(\frac{t}{T}\right)^1 + 0.630 \quad (5)$$

Where,

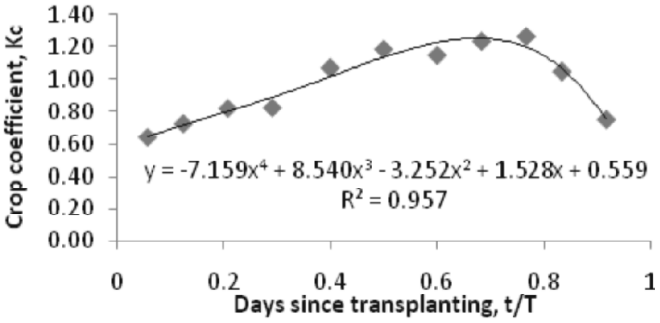
Kc_t = crop coefficient on t^{th} day

t = number of days since transplanting

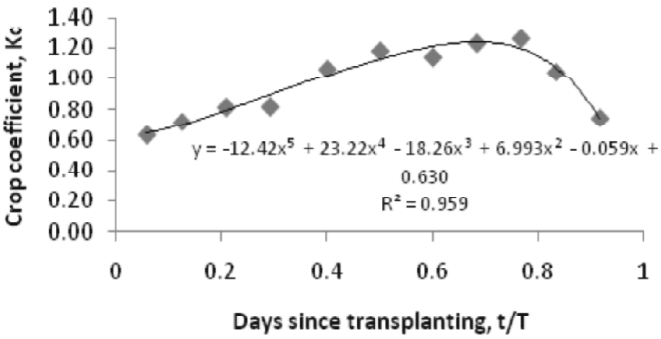
T = total crop period



(a) 3rd order polynomial equation



(b) 4th order polynomial equation



(c) 5th order polynomial equation

Figure 1: Crop coefficient curve for onion (2012)

The K_c of the onion ranged from 0.63 to 1.26 for 2012season. The least values in the ranges above were either at the beginning of the season (which may be taken as the K_c initial) or towards the end of the season (which may be taken as K_c end), while the highest values were during the mid season (which may be taken as K_c mid). The K_c mid values were recorded at the latter part of bulb formation to earlier part of bulb enlargement stages.

According to FAO-56, the crop coefficient values for onion during the initial, mid season and late season are 0.70, 1.05 and 0.75 respectively.

CONCLUSION

The estimated values of Kc during the initial, mid-season, and late season were 0.63, 1.26 and 0.74, respectively. The crop coefficient values of onion are represented by the following function of the ratio of number of days since transplanting to total crop growth period for semiarid tropics of Maharashtra.

$$K_c = -12.42 + 23.22 - 18.26 + 6.99 - 0.059 + 0.630$$

$$(R^2 = 0.95)$$

K_c can be well predicted by the fitted fifth-order polynomial functions expressed as DAT. The estimated K_c values in this paper can be used to manage irrigation scheduling for onion crop under the similar agro-climatic conditions.

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