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COMPARATIVE EVALUATION OF VARIOUS NDVI MODELS TO ESTIMATE CROP CO-EFFICIENT FOR SUMMER SESAME

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Abstract: Crop co-efficient estimation using best suited NDVI models for summer sesame based on single crop coefficient approach for South Gujarat Agro Climatic Zone of Gujarat was carried out at college farm, CAET, NAU, Dediapada. Field experiment was conducted during summer season of 2019. The NDVI data was captured using Field Scout CM 1000 NDVI Meter on weekly basis during growing period of the crop. The FAO crop co-efficient data was taken from FAO irrigation and drainage paper no. 56. Drip and surface control irrigation system were used as treatments. The crop co-efficient was directly estimated from NDVI value using NDVI-K_c Models. There were four different models was used in study. The stage wise crop co-efficient was derived from the stage wise average NDVI data for each model separately. This stage wise crop co-efficient data of various models were compared with the FAO crop co-efficient data for both systems. The regression analysis derived R^2 values for Muttibwa & Irmak, Kamble, Singh & Irmak and Vashisht models were 0.918, 0.926, 0.930 and 0.868 for drip irrigation system and 0.840, 0.850, 0.857 and 0.856 for surface control irrigation system respectively. The Singh & Irmak model was mostly suitable for *summer sesame* crop for Narmada region among the available models and can be used to determine crop coefficient (K_c) value for Narmada region.

Keywords: Crop Coefficient, FAO 56, Drip Irrigation System, Surface Control Irrigation System, NDVI-K_c Models.

INTRODUCTION

Water is the elixir of life and essential for socio-economic development of any region. In most regions of the world, over 70 percent of freshwater is used for agriculture. By 2050, feeding a planet of 9 billion people will require an estimated 50 percent increase in agricultural production and a 15% increase in water withdrawal (Grafton *et al*., 2015). In order to minimize the losses of water during irrigation, a proper scheduling of irrigation is required. The amount of water required in any field is equal to the evapotranspiration (ET_c) of the field. The most common and practical approach used for estimating crop water requirements is the FAO-56 method (Allen *et al.,* 1998). This method used reference evapotranspiration ET_0 and crop coefficients (K_c) to determine crop evapotranspiration (ET_c) under unrestricted water availability. The reference evapotranspiration (ET_0) represents the

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climatic demand of the atmosphere while the crop coefficient represents the differences distinguishing the reference crop and the considered crop in terms of ground cover, canopy properties and aerodynamic resistance, thus in terms of crop evapotranspiration. The crop coefficient can be directly determined from the Reflectance Based Vegetation Indexes. A vegetation index is a quantitative measure used to measure the biomass or vegetative vigor usually from combination of several spectral bands (range of wavelength), whose values are added, divided, multiplied in order to yield a single value that indicates the amount or vigor of vegetation. Numbers of models were developed to determine value of K_c directly from the NDVI of the crop. NDVI is a numerical indicator that uses the visible and near infrared bands of the electromagnetic spectrum and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not. An attempt has been made to evaluate the various available NDVI-Kc Models with the main objective of comparative evaluation of various NDVI models to estimate crop co-efficient for summer sesame.

MATERIAL & METHOD

Study Area

A field experiment was conducted during the year of 2019 at the farm of College of Agricultural Engineering and Technology, Navsari Agricultural University, Dediapada, Gujarat. Research site is situated at 21°62'68"N latitude, 73°58'59"E longitude and an altitude of 169 m above mean sea level. The location of the study area is shown in Plate 1. Dediapada is situated in the Narmada district of South Gujarat Agro Climatic Zone in Gujarat.

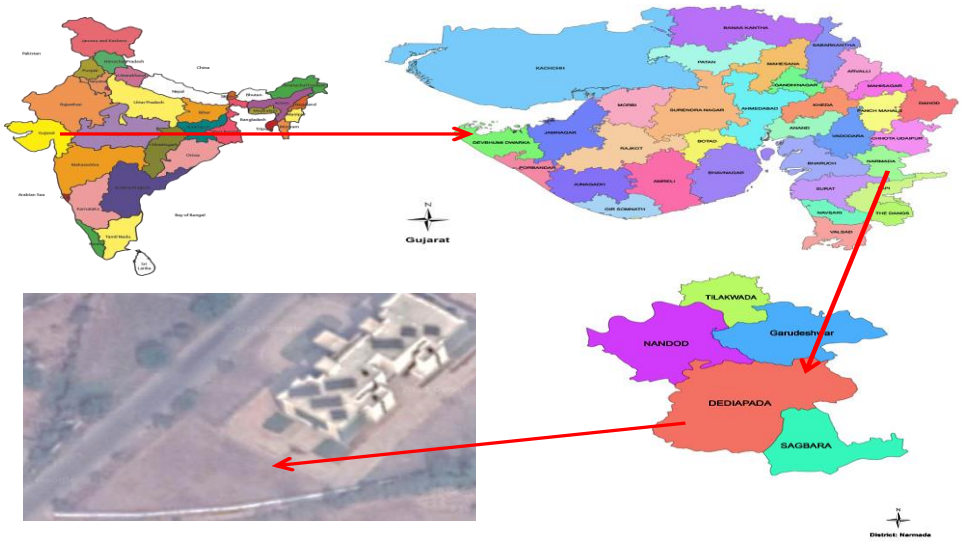

Plate 1. Location Map of Study Area

The average annual rainfall of the tract is about 1139 mm, average maximum and minimum temperature are 34.4 and 22.0 (^{0}C), average maximum and minimum relative humidity are 73.1 and 41.5 (%), average annual wind speed 5.4(km/hr). Average annual bright sunshine hour is 7.2 (hr), average annual evaporation is 10.3 (mm). In general, monsoon is commenced by the second fortnight of June and ceases by September end. The rainfall is distributed over the entire kharif season, but the concentration of the rain is more during the months of July and August (Lakkad and Shrivastava, 2016).

Crop Co-efficient Estimation

Crop coefficient data for each crop growth stage of summer sesame have been collected from the FAO irrigation and drainage paper no. 56. The Field Scout CM 1000 NDVI Meter uses "point-and-shoot" technology to instantly measure reflected light in the red (660nm) and near infrared (840nm) spectral bands. This instrument uses red and near infrared reflectance to calculate normalized difference vegetation index (NDVI). This NDVI meter has been used to collect weekly NDVI data from the crop and soil during the crop period.

Treatment Details

1. Treatments**:** I. Drip Irrigation System

II. Surface Control (Border Irrigation System)

2. Plot size: I. Net Plot size = 408.24 m^2

II. Bad size = 5.4 m × 4.5 m

3. Crop: Sesame (GT -2)

4. Crop Season: Summer

5. Distance between two plots: 0.6 m

6. Crop Spacing: 30 x 15 cm

7. Direction of sowing: North – South

NDVI Measurements and Determination of Crop Coefficient (K_c)

Field Scout CM 1000 NDVI Meter was kept about 30 to 45 cm above the crop canopy with a 90 degree angle to the canopy to record the NDVI values of crop canopy and soil surface. The NDVI was measured at 7 day intervals between 12.00 to 13.00 clocks.

NDVI K_c Models

The number of models was developed to determine crop coefficient (K_c) directly from NDVI value. These models are in the foam of linear equation which shows the relationship between K_c and NDVI value. From the available various models, four NDVI K_c models have been used for the study. These models are shown in Table 1.

Table 1: List of different models with its equation

No.	Model Name	Equation
1.	Muttibwa & Irmak Model	$K_c = 1.58(NDVI) – 0.111$
2.	Kamble Model	$K_c = 1.4571(NDVI) – 0.1725$
3.	Singh & Irmak Model	$K_c = 1.31(NDVI) + 0.027$
4.	Vashisht Model	$K_c = 1.195(NDVI) – 0.057$

Comparison of different NDVI Models K_c with FAO K_c:

The crop coefficient value for each NDVI model for both drip and surface control irrigation treatment were computed. These individual K_c values were compared with FAO K_c for both treatment separately in order to judge the suitability and adaptability of these models for Dediapada regions for summer sesame crop.

RESULTS AND DISCUSSIONS

FAO Crop Coefficient

Crop coefficient (K_c) for each growth stages of summer sesame crop was collected from FAO paper-56 for each stage and presented in Table 2.

Table 2. FAO Crop Coefficient (K_c) for Summer Sesame

No	Development Stages	Drip System	Control System
1.	Initial stage	0.72	0.73
2.	Development stage	0.95	0.97
3.	Mid stage	1.06	1.05
4.	End stage	0.64	0.74

Normalized Difference Vegetation Index (NDVI) Data

The NDVI values collected from Field Scout NDVI meter for surface control and drip irrigation system for summer sesame during crop growing period on weekly basis are presented in Table 3.

Table 3. Stage wise Average Measured NDVI value

No	Development Stages	Drip System	Control System
1.	Initial stage	0.58	0.61
2.	Development stage	0.67	0.70
3.	Mid stage	0.84	0.81
4.	End stage	0.46	0.51

Different NDVI Models use for Estimation of Crop Coefficient

The stage wise crop coefficients were estimated using the stage wise NDVI dataof different NDVI models for both drip and surface control treatments. The stage wise K_c values for different four NDVI models are presented in Table 4.

Table 4: Crop Coefficient (K_c)

No	Development Stages	NDVI K_c Models							
		Muttibwa & Irmak Model		Kamble Model		Singh & Irmak Model		Vashisht Model	
		Drip	Control	Drip	Control	Drip	Control	Drip	Control
1.	Initial stage	0.81	0.85	0.67	0.72	0.79	0.82	0.68	0.67
2.	Development stage	0.94	0.98	0.80	0.85	0.91	0.94	0.74	0.78
3.	Mid stage	1.21	1.18	1.05	1.02	1.13	1.09	0.95	0.92
4.	End stage	0.61	0.69	0.49	0.57	0.63	0.69	0.49	0.55

Comparison of FAO $K_c$with NDVI Model K_c

FAO crop coefficients (Kc) were compared with NDVI models crop coefficient (K_c) for both drip and surface control irrigation system. The regression analysis indicates that there are a linear relation exists between the FAO K_c and NDVI Model K_c.

Comparison of K_c value of FAO and Muttibwa & Irmak model are shown in fig. 1 and 2 for drip irrigation system and surface control irrigation system respectively. Comparison of K_c value of FAO and Kamble model are shown in fig. 3 and 4 for drip irrigation system and surface control irrigation system respectively. Comparison of K_c value of FAO and Singh & Irmak model are shown in fig. 5 and 6 for drip irrigation system and surface control irrigation system respectively. Comparison of K_c value of FAO and Vashisht model are shown in fig. 7 and 8 for drip irrigation system and surface control irrigation system respectively.

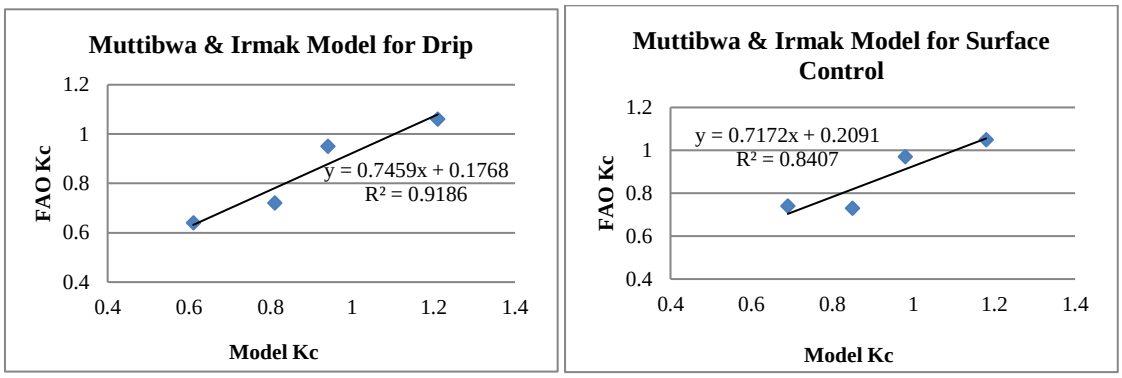

Fig. 1: Comparison of Muttibwa& Irmak Model K_c and FAO K_c for Drip and Surface Irrigation System

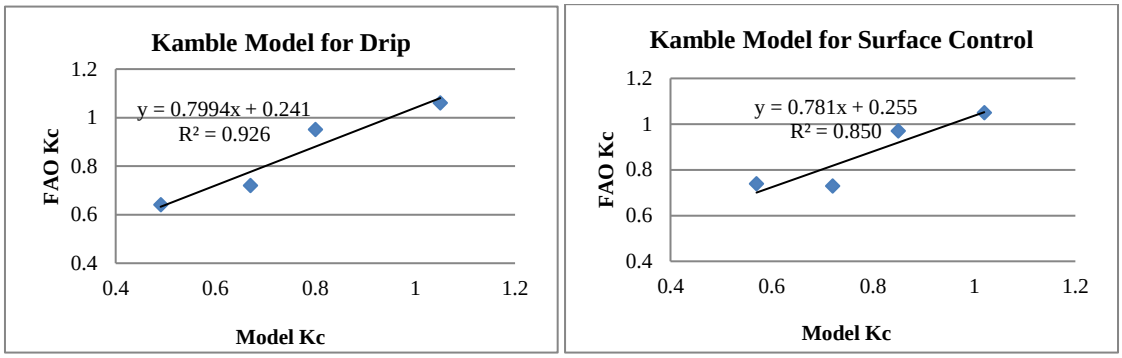

Fig. 2. Comparison of Kamble Model K_c and FAO K_c for Drip and Surface Irrigation System

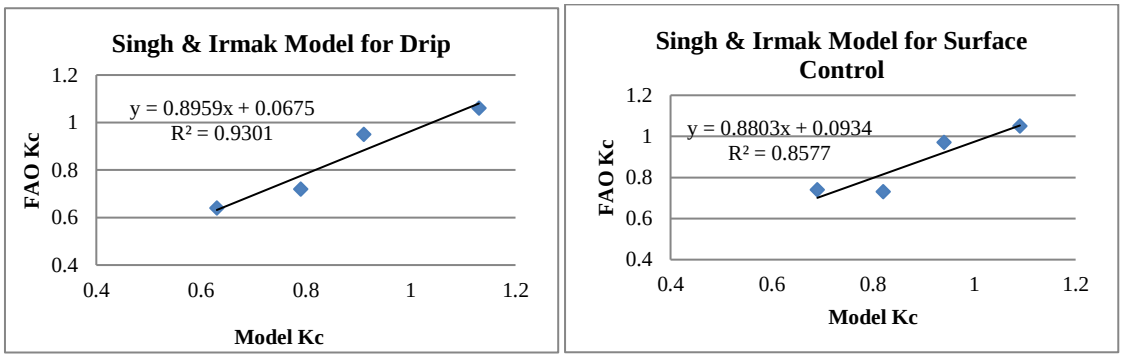

Fig. 5: Comparison of Singh & Irmak Model K_c and FAO K_c for Drip and Surface Irrigation System

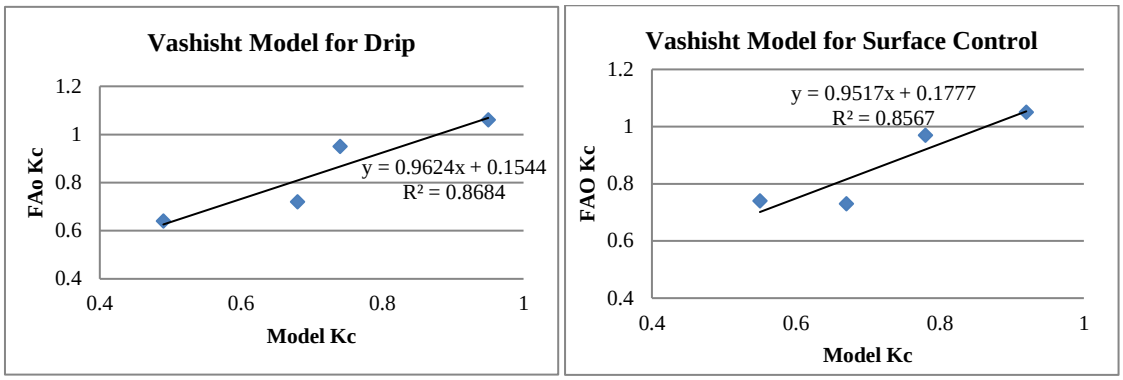

Fig. 7: Comparison of Vashisht Model K_c and FAO K_c for Drip and Surface Irrigation System

CONCLUSION

The comparison of Muttibwa and Irmak model K_c with FAO K_c resulted R^2 of 0.918 for drip irrigation system and 0.840 for surface control irrigation system. The comparison of Kamble model K_c value with FAO K_c values provides R^2 of 0.926 for drip irrigation system and 0.850 for surface control irrigation system. The comparison of Singh and Irmak model K_c with FAO K_c values computed R^2 value of 0.930 for drip irrigation system and 0.857 for surface control irrigation system. The comparison of Vashisht model K_c with FAO K_c given R^2 of 0.868 for drip irrigation system and 0.856 for surface control irrigation system. From the all these comparisons, the study shows that, the Singh & Irmak model provide the highest R^2 for both drip and surface control system. Therefore, the study suggest that the Singh & Irmak model is mostly suitable for summer sesame crop for Narmada region and can be used the model for determine crop coefficient (K_c) value for Narmada region among the available NDVI Models.

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