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Influence of different irrigation regimes on the potential yield of blackgram (*Vigna mungo*) under Periyar Vaigai command areas

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Abstract
The production potential of black gram under irrigated dryland conditions can significantly be improved by selecting suitable variety and matching the crop water requirement at suitable intervals. Therefore, a field trial was conducted during summer season of 2021 at Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu to examine the potential yield of blackgram varieties influenced by various irrigation regimes. The experiment was carried out in strip plot design with three irrigation regimes 100% ETc, 75% ETc, 50% ETc and five black gram varieties ADT 3, ADT 6, VBN 8, VBN 11, TBG 104 and each treatment was replicated thrice. Blackgram variety VBN 11 irrigated under 75% ETc resulted higher in plant height (40.45cm), number of branches/plant (19.68), haulm yield (1786 kg/ha). Irrigation scheduling under 75% Etc for blackgram var. ADT 3 recorded lower yield gap of 35.03%. From the study, it could be concluded that, application of irrigation based on the ETc requirement (75%) can significantly increase the yield and performance of black gram var. VBN 11.

Keywords: Blackgram, varietal selection, irrigation scheduling, root, shoot ratio, yield gap

Introduction
India is the world's biggest producer and consumer of blackgram (*Vigna mungo* L.). In India, blackgram ranks fourth in terms of output, producing 1.5 million tonnes per year from around 2.5 million hectares of land with an average yield of 400 kg/ha. Blackgram production accounts for about 10% of India's total pulse output. In Tamil Nadu, blackgram is one of the most important pulses, accounting for 41% of the total area under pulses. The state's blackgram area is around 4.26 lakh ha, with a yield of 3.016 lakh tonnes and an average productivity of 707 kg/ha (Department of Agriculture, 2020) [4].
Moreover, aberrant weather conditions have led to decreased productivity. This has led to economic losses to the farmers due to the partial or total failure of blackgram crop discouraging the farmers from further cultivation. In addition, the shortage of pulses along with oilseeds has aggravated malnutrition (Hussainy and Vaidyanathan, 2019) [7].
Summer irrigated blackgram is being raised after the harvest of Samba/Thaladi paddy, in Periyar Vaigai Command Area of Tamil Nadu, where the ground water level is sufficient. Despite the fact that blackgram requires minimum water (350 – 400 mm), water constraints throughout the summer prompted farmers to forego planting. Pulses usually suffer either due to excess or shortage of water (Ramesh *et al.*, 2016) [12]. Excess water depletes plant available nutrients, reduces air availability, and causes land to become waterlogged. Irrigation should be delivered at the correct time, in the right amount, and in the suitable manner in order to reap long-term advantages. The physiological stages of crop growth are proven to be highly significant in terms of water demand. Improved techniques are needed for accurate quantification of evapotranspiration on a field to enhance efficient use of water resources and protect environment and water quality (Sharma *et al.*, 2020) [14].
According to a study done by (Shirgapure and Fathima, 2018) [15], using the optimal amount of irrigation (75% ETc) improved the yield of blackgram to 1878.69 kg/ha above surplus irrigation. Furthermore, selecting an appropriate variation and assessing it in a constrained environment is critical. In the same agro-ecology, Haque *et al.* (2019) [6] discovered that variety BARI mush–3 recorded (1.69 t/ha). Water use efficiency can be improved by making ensuring irrigation water matches crop evapotranspiration and is applied during crucial growth stages (Ibrahim *et al.*, 2002) [9].

Therefore, the current study aimed to examine the influence of irrigation regimes on different varieties of blackgram under moisture stress condition.

Materials and Methods

The research was carried out in the Department of Agronomy, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, in the year 2021, under irrigated conditions. The experimental site is located at 9º 54´ North latitude and 78º 54´ East longitude, with a height of 147 metres above sea level. The area has an average annual rainfall of 852.8 mm, with daily maximum and minimum temperatures ranging from 35.2 °C to 18.9 °C. The soil sample was neutral in pH, sandy clay loam in texture (26.7% coarse sand, 34.5% fine sand, 12.3% silt, and 26.5% clay), low in organic carbon (0.42%), low in accessible nitrogen (232.6 kg/ha), medium in phosphorus (19.6 kg/ha), and medium in potassium (246.4 kg/ha). Figure 1 shows the weather data collected during the experiment.

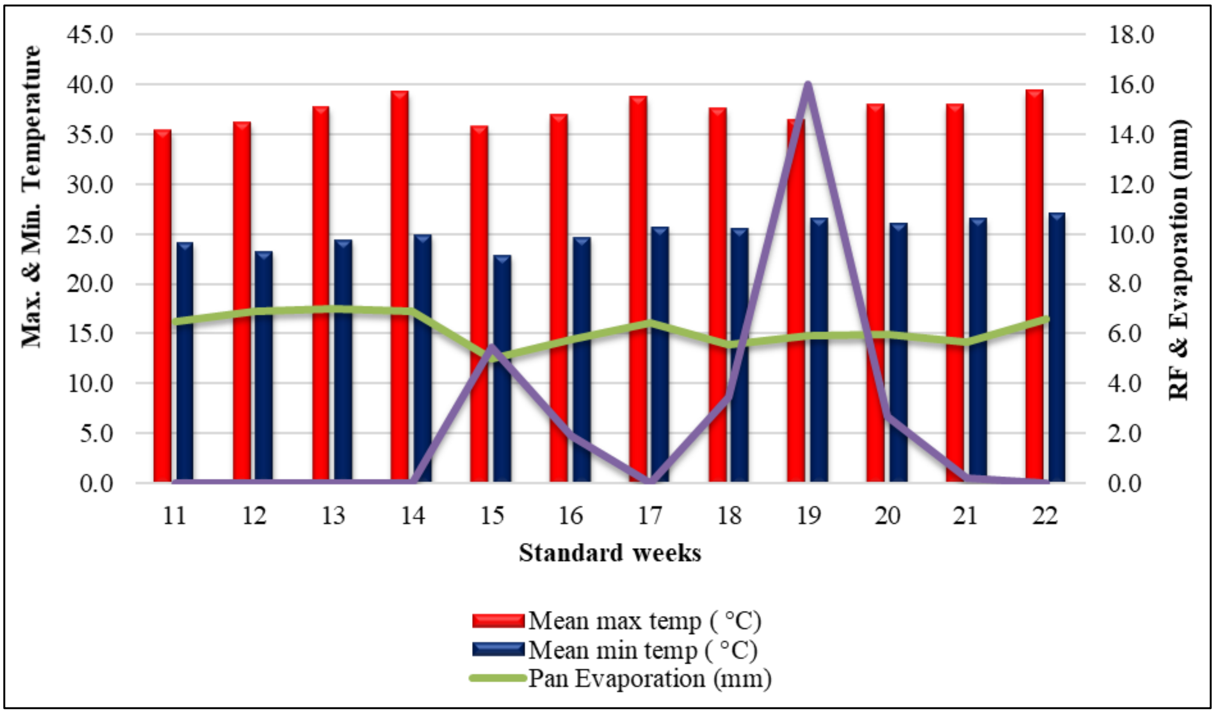

Fig 1: Weather data during crop growth period

The experiment included three irrigation regimes of 100% ETc (I_1), 75% ETc (I_2) and 50% ETc (I_3) of crop water requirement (ETc), as well as five black gram varieties *viz.*, ADT 3 (V_1), ADT 6 (V_2), VBN 8 (V_3), VBN 11 (V_4), TBG 104 (V_5) were laid out in a strip plot design with irrigation levels as the vertical strip and varieties as the horizontal strip. Each treatment combination was allocated to the experimental units within a strip randomly and replicated thrice.

All plots received irrigation on the day of sowing (DAS), followed by life irrigation on the third DAS. Consecutively, irrigation was provided according to the treatment based on daily pan evaporation data. To determine the volume of water supplied to the plot, the irrigation water was quantified using a Parshall flume (3-inch throat) and the time necessary was recorded using a stop watch. Buffer channels were installed around each experimental plot to prevent irrigation water from infiltrating the next plot.

The evaporation losses were measured with an open pan evaporimeter, and the irrigation water needed was estimated by calculating ETc using the formula of Doorenbos and Pruitt (1977) [5].

$$ETc = ETo \times Kc$$

Where, ETc - Crop Evapotranspiration; ETo - Reference Evapotranspiration; and Kc - Crop factor.

The crop factor at different stages of crop growth i.e., seedling (0.63), vegetative (1.18), flowering (1.19) and maturity (0.54) were used as per the (FAO, 1991) [1].

The size of the experimental plot was 3.5 × 6.5 m (22.75 m^2) 11 rows (lines) and black gram was sown on 16.03.2021 with a spacing of 30 × 10 cm. For all the treatments, the fertilizer doses were applied basally at the rate of 25:50:25 kg NPK/ha) in the form of Urea, di-ammonium phosphate, and muriate of potash. To develop the crop successfully, all of the prescribed agronomic procedures were followed according to the TNAU Crop Production Guide, 2020 [2].

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Observations were recorded on the plant height (cm), number of branches, root shoot ratio, haulm yield (kg/ha), harvest index were measured. Percent yield gap was estimated using the yield component between the potential yield and actual yield and was expressed as percentage.

$$\text{Percent yield gap (\%)} \frac{\text{Estimated yield} - \text{Actual yield}}{\text{Estimated yield}} \times 100$$

The data collected were statistically analysed for strip plot design using Analysis of Variance (ANOVA) at the 5% level of significance using the STAR software from IRRI, Philippines.

Results and Discussion

Plant growth

The growth of blackgram was significantly influenced by irrigation levels. The data revealed that, higher plant height was recorded in 75% ETc for blackgram var. VBN 11 (40.45cm) followed by TBG 104 (37.52cm) while lower height was recorded at irrigation under 50% ETc in blackgram var. ADT 3 (Table 1). Irrigation at 75% ETc may have met the crop water need at appropriate intervals, significantly increasing growth and the physiological processes of the plant, such as photosynthesis, assimilation, and translocation, resulting in the increase of plant height through cell division and cell enlargement (Sisay *et al.*, 2018; Merkebu, 2014) [17, 11]. Blackgram var. VBN 11 irrigated under 75% ETc recorded superior in number of branches per plant (19.68) followed by TBG 104 (19.08) and the lower number of branches (11.82) were recorded at irrigation under 100%ETc in blackgram var. ADT 3 (Table 1). The findings of Raza *et al.* (2012) [13] corroborate with the results.

Similarly, other irrigation regimes based on ETc were identified inferior when supplied based on 75% ETc. The rise can be ascribed to the crop receiving the optimum level of irrigation during its growth period, contributing to increased and more efficient nutrient use. The results are similar to the findings of Hussen *et al.*, (2019) [8].

Irrigation levels had a substantial impact on the root shoot ratio. Adaptions to drought include a well-structured root system that enhances the plant's ability to gather water (Jaleel *et al.*, 2008) [10]. In this study, it was seen that root length increased as drought stress increased. This increase in root length in dry soils, as well as the formation of a deep-rooted root network, would help plants in effectively absorbing moisture and is one of the methods through which blackgram plants tolerate drought stress. Another strategic adaptation to increase tolerance to soil moisture deficit is a high root to shoot ratio found in low soil moisture content. Thus plants with longer roots are able to more effectively compete for soil nutrients and water, while those with a higher proportion of shoots can collect more light energy.

The decreased supply of water to the 50% ETc plots lead to deeper root system as a result of diverted photosynthate energy in search of water. The results are in concordance to the results of Behera *et al.* (2015) [2].

Table 1: Effect of irrigation regimes on plant height at peak growth phase, number of branches per plant and pods per plant

Treatments	Plant height (cm)			Number of Branches per plant			Pods per plant		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
V_1	25.09	23.20	22.97	11.82	12.45	15.91	22.95	25.42	26.08
V_2	26.88	29.92	24.92	13.34	16.41	14.70	25.28	30.73	28.78
V_3	28.67	33.95	27.27	15.62	18.90	16.28	27.90	35.19	31.30
V_4	34.09	40.45	32.83	16.31	19.68	17.96	31.44	42.62	35.39
V_5	30.77	37.52	29.30	15.91	19.08	17.02	29.48	38.13	33.05
S.Em±	0.34			0.85			1.24		
CD (P=0.05)	1.02			2.54			3.71		

I_1: 100% ETc I_2: 75% ETc; I_3: 50% ETc; V_1: ADT 3; V_2: ADT 6; V_3: VBN 8; V_4: VBN 11 and V_5: TBG 104

Yield and yield attributes

The yield potential of blackgram crop is determined by the yield component. The results show that variations in irrigation regimes substantially impacted the number of pods/plant. Higher number of pods per plant of 42.62 was recorded with irrigation under 75% ETc for blackgram var. VBN 11 followed by TBG 104 with (38.13) while irrigation under 100%ETc for blackgram var. ADT 3 recorded the lower number (38.63) of pods/plant**.** Similarly, higher haulm yield under 75% ETc to the tune of 1786 kg/ha was recorded in blackgram var. VBN 11 (Table 2).

The improved performance might be attributed to appropriate soil moisture content as a consequence of optimal irrigation amount during the crop growth period, allowing for greater nutrient absorption and source sink partitioning. This is in concordance to the findings of Singh and Singh (2016) [16]. Harvest index were not significantly affected by the intercropping system as well as irrigation scheduling.

Table 2: Effect of irrigation regimes on root shoot ratio, percent yield gap, haulm yield and harvest index

Treatments	Root shoot ratio			Percent yield gap			Haulm Yield (kg/ha)			Harvest Index		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
V_1	0.13	0.20	0.23	39.4	38.0	35.3	1103	1171	1201	0.34	0.35	0.36
V_2	0.18	0.21	0.23	43.4	43.6	45.5	1326	1193	1120	0.36	0.39	0.38
V_3	0.18	0.21	0.23	39.7	44.3	50.1	1339	1304	1342	0.37	0.40	0.37
V_4	0.19	0.22	0.23	44.9	48.5	54.0	1320	1786	1428	0.38	0.35	0.37
V_5	0.18	0.21	0.23	42.8	46.5	50.8	1368	1562	1438	0.36	0.36	0.35
S.Em±	0.009			-			65.31			0.01		
CD (P=0.05)	0.027			-			195.783			NS		

NS: Not Significant; I1: 100% ETc I2: 75% ETc; I3: 50% ETc; V1: ADT 3; V2: ADT 6; V3: VBN 8; V4: VBN 11 and V5: TBG 104

Percent yield gap

Higher percent yield gap was noted at irrigation under 75% ETc for blackgram var. VBN 11 (54%) followed by TBG 104 with (50.79%). Lower values (38.03%) were observed in combination of 50% ETc for blackgram var. ADT 3 (Table 2). The estimated yield was computed using the yield attributes, and enhanced yield attributes were seen as a result of the crop's improved performance. Similarly, the percent yield gap demonstrated the efficient translation of yield components to crop yield. Irrigation scheduling of 75%ETc effectively converted the yield attributes to the yield of the crop which could be attributed to the optimized quantity of water made available to the crop which resulted in conversion of photo assimilates to the sink increasing the yield of the crop. The results are in similarity to the observations of Rao *et al.* (2015).

Conclusion
From the study it can be confirmed that, irrigation based on crop evapotranspiration is a more appropriate approach wherein 75% ETc resulted in improved growth, yield characteristics, and yield besides with lesser water requirement. Therefore, selection of blackgram var. VBN 11 is more suitable for higher productivity under Periyar Vaigai command areas of Tamil Nadu, India.

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