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Growth and productivity of cowpea under different irrigation schedules

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Abstract
A field experiment entitled "Growth and Productivity of Cowpea under Different Irrigation Schedules" was carried out during summer season, 2022 at Research Farm of Forage Section, Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University. The experiment consisted of three irrigation schedules *viz*. irrigation at 7, 11 and 15 days interval and four cowpea varieties *viz*. RC 101, GC 1601, PGCP 24 and HC 46. The experiment was laid out in split plot design with three replications. The soil of the experimental site was sandy loam having pH 7.9, EC 0.32 dS m^{-1} and organic carbon 0.46% with low available nitrogen (125 kg ha^{-1}), medium phosphorus (13.5 kg ha^{-1}) and medium potassium (290 kg ha^{-1}) status. Significantly highest dry matter accumulation (16.44 g) and leaf area index (9.75) were recorded at harvest under irrigation scheduled at 7 days interval. Seed yield at irrigation schedule 11 days interval was 3.6% and 36% higher as compared to seed yield under 15 and 7 days interval. Maximum gross returns (59369 ₹ ha^{-1}) and net returns (29.579 ₹ ha^{-1}) were fetched under irrigation scheduling at 11 days interval but highest BC ratio (1.93) was fetched under irrigation schedule at 15 days interval. Among varieties, maximum seed yield (937 kg/ha), gross returns (61809 ₹ ha^{-1}), net returns (29353 ₹ ha^{-1}) and BC ratio (1.93) was fetched in variety GC 1601 which was at par with variety PGCP 24 and superior than variety RC 101 and HC 46.

Keywords: Cowpea, varieties, irrigation scheduling, seed yield and economics

Introduction
Cowpea (*Vigna unguiculata* L. Walp) belongs to the family Fabaceae and commonly called as black-eyed pea or black-eyed bean. It's a warm-season annual pulse crop with a wide range of uses. The cowpea seeds are good source of protein for human, while the haulm is used as a source of protein for livestock (Belay *et al*., 2017) [6]. It is an important grain crop, particularly in arid and semi-arid regions of the tropics and sub-tropics. It contains 50-60% carbohydrates and 23-32% protein (Kirse & Karklina, 2015) [10], vitamin A and C, iron, phosphorus, calcium (Liyanage *et al*., 2014) [14] and amino acids like tryptophan and lysine (Arul Prakasham *et al*., 2019) [4].

The crop is adaptable to a variety of soil types and climatic conditions in the humid tropics and subtropics. The crop has a great ability to fix atmospheric nitrogen through root nodules to improve soil fertility, stop soil erosion through a deep tap root system, and supply a significant amount of organic matter that will likely be useful for the subsequent crop as well as soil health sustenance (Namakka *et al*., 2017) [15]. It is typically adapts to various biotic and abiotic stresses like drought, high temperatures and other factors better than other crop plant species.

Africa accounts for the majority of the world's production (96.7%), with Nigeria (3.6 million tons) being the largest producer in 2019 (FAO, 2021). Among advanced countries, only the United states is a notable producer and exporter of cowpea. Asia has been ranked second to Africa, In terms of production. It is cultivated in *kharif* and summer season as vegetable and grain pulse crop in India. Cowpea grown over an area of 0.5 m ha in India **(**Rajput and Rana, 2016) [16]. The area, production and productivity of cowpea is integrated with beans in India. Rajasthan, U.P., M.P., Bihar, West Bengal, Punjab, and some areas of H.P. are notable growers of cowpea. (Aishwerya, 2018) [2].

Soil water depletion impacts growth and yield, and are important aspects that have an impact on food production (Kuchenbuch *et al*., 2006) [11]. however, legume crops have unique characteristics of their high susceptibility to both water stress and water logging through out of their growing season. thus, proper irrigation scheduling helps to preserve moisture, lowering weed growth and maximizing yield (Ghosh and Panja, 2016) [9].

Cowpea is more susceptible to moisture stress especially during flowering and pod filling stages (Aboamera, 2010) [1]. Despite the crop being primarily grown in dry land conditions, it responds positively to irrigation application. The amount of water utilized by the crop during the growth stage and lost via the soil or plant (as evapotranspiration) is a key determinant of yield outputs. Hence, in given soil and climatic conditions, appropriate intervals of irrigation application is important in economizing irrigation water and optimizing crop yield.

Some varieties have genes which promote faster growth and higher biomass production while others may have the genes which promote higher uptake of nutrients. Some have resistance toward biotic and abiotic stress i.e. moisture and temperature and can survive efficiently in drought conditions of arid and semi-arid areas while, some are better in utilizing the applied nutrient like irrigation and fertilizer and perform superior than others. Although numerous varieties/hybrids and agricultural methods have been created, cowpea productivity has not yet reached the expected level. The yields of conventional farms and those of experimental fields differ significantly. Thus to achieve high yields per unit area at farmers field it is important to identify the most effective genotypes for the local ecological circumstances (Carvalho *et al*., 2022) [7]. Hence, supplemental irrigation at critical growth stages during hot summer months and suitable varieties are very critical to realize the potential yield.

Materials and Methods

The study was carried out at Research area of Forage Section Research Farm, Department of G&PB, Chaudhary Charan Singh HAU, Hisar, during summer season 2022. In north western India, Hisar is located at longitude 75°46'E, latitude 29°10'N, and at an elevation of 215.2 m above MSL in Haryana. The weekly weather data recorded during the crop season is presented in Fig. 1. It indicates that the mean weekly maximum and minimum temperature ranged from 44 to 27.1 °C and 28.6 to 10.5 °C, respectively, during the crop growth period. The weekly mean relative humidity ranged from 46 to 93% in morning hours and 17 to 50% in evening hours. The experiment was carried out in Split plot design comprised of three irrigation schedules in main plot: I_1: Irrigation at 7 days interval, I_2: Irrigation at 11 days interval, I_3: Irrigation at 15 days interval and four varieties in sub plot: V_1: RC 101, V_2: GC 1601, V_3: PGCP 24, V_4: HC 46. The soil was sandy loam having pH 7.9, EC 0.32 dS m^{-1} and organic carbon 0.46% with low available nitrogen (125 kg ha^{-1}), medium phosphorus (13.5 kg ha^{-1}) and medium potassium (290 kg ha^{-1}) status. 20 kg N and 40 kg P_2O_5 per ha was applied through urea and DAP as a basal dose and row spacing was 45 cm. Irrigations were applied as per the treatments. The data were analyzed using appropriate analysis of variance (ANOVA). OPSTAT software was used to carry out statistical analysis.

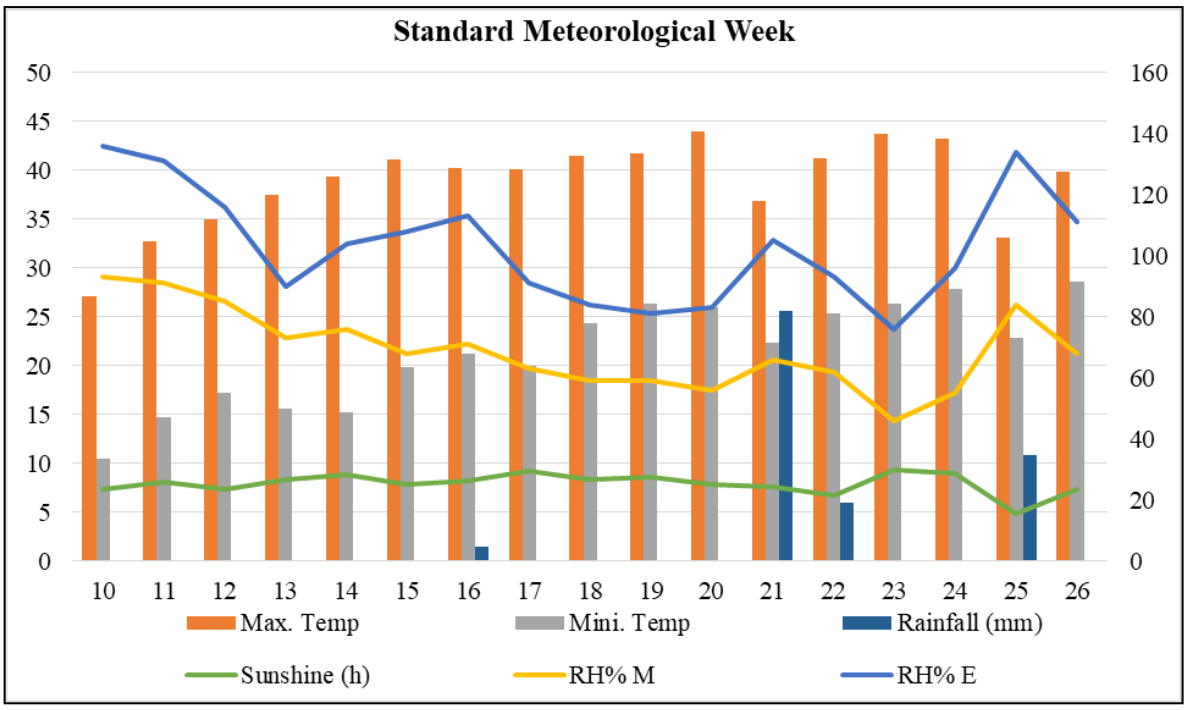

Fig 1: Mean weekly meteorological data during the crop growing season 2022 recorded at experimental area, CCS HAU, Hisar

Results and Discussion

Growth parameters

Data presented in Table 1 indicated that irrigation application at different intervals significantly affected dry matter accumulation in cowpea varieties. Significantly higher dry matter accumulation of (1.27, 5.02, 17.43 and 16.44g) at 30, 45, 60 DAS and at harvest were recorded when irrigation was scheduled at 7 days interval, followed by irrigation at 11 days interval with accumulation of 1.1, 4.51, 13.50 and 12.80 g dry matter at periodical interval of 30, 45, 60 DAS and at harvest. Minimum accumulation of dry matter was noted with irrigation scheduling at 15 days interval with dry matter accumulation of 1.03, 4.13, 11.64 and 10.80g at 30, 45, 60 DAS and at harvest, it was at par with irrigation scheduling at 11 days interval at 30 DAS. Effect of different irrigation schedules on leaf area index in cowpea varieties is shown in Table 2 and it was observed

from the data that irrigation scheduling had significant effect on leaf area index of cowpea varieties. Significantly higher leaf area index of 0.31, 2.41, 7.16 and 9.75 were noted at 30, 45, 60 DAS and at harvest with irrigation at 7 days interval, followed by irrigation at 11 days interval with leaf area index of 0.25, 2.08, 5.77 and 8.42 at 30, 45, 60 DAS and at harvest. Significantly minimum leaf area index of 0.23, 1.94, 5.16 and 7.94 were recorded at 30, 45, 60 DAS and at harvest when irrigation was applied at 15 days interval. Probably optimal supply of soil moisture in the surrounding of root zone under irrigation at 7 days interval had favorably improved the uptake and translocation of nutrients. On the other hand, optimal soil moisture conditions may have encouraged cell enlargement and division, which led to stem elongation which ultimately linked with the plant growth and developments in terms of dry matter accumulation and leaf area index. These findings concur with results reported by Anita and Lakshmi (2015) [3] and Saleh *et al.* (2018) [17].

Varieties also showed significant variation in dry matter accumulation (Table 1). Maximum dry matter was accumulated in variety RC 101 with values of 1.27, 4.65, 14.84 and 14.19g at 30, 45, 60 DAS and at harvest, followed by GC 1601 and HC 46 which were at par with each other with corresponding values of (1.16, 4.57, 14.17 and 13.52g) and (1.12, 4.54, 14.30 and 13.31g). Minimum accumulation of dry matter was obtained in variety PGCP 24 with values of 1.06, 4.45, 13.46 and 12.37g at 30, 45, 60 DAS and at harvest, it was at par with variety HC 46 at 30 and 45 DAS and at harvest. Varieties also differ in leaf area index (Table 2). Variety RC 101 recorded maximum leaf area index of 0.27, 2.28, 6.44 and 9.20 at 30, 45, 60 DAS and at harvest, followed by variety GC 1601 and HC 46, which were at par with each other with respective leaf area index of (0.26, 2.21, 6.06 and 8.80) and (0.25, 2.16, 6.03 and 8.69). The lowest leaf area index was recorded in variety PGCP 24 with values of 0.25, 1.93, 5.59 and 8.13 at 30, 45, 60 DAS and at harvest. PGCP was also found at par with GC 1601 and HC 46 at 30 DAS. The difference might be due to genetic makeup of different varieties. Similar findings were observed by Asati *et al.* (2018) [5].

Table 1: Effect of irrigation scheduling on dry matter accumulation per plant (g) of cowpea varieties

Treatments	At 30 DAS	At 45 DAS	At 60 DAS	At harvest
Irrigation schedules				
Irrigation at 7 days interval	1.27	5.02	17.43	16.44
Irrigation at 11 days interval	1.10	4.51	13.50	12.80
Irrigation at 15 days interval	1.03	4.13	11.64	10.80
SE(m)±	0.02	0.05	0.27	0.24
CD (P=0.05)	0.10	0.18	1.07	0.94
Varieties				
RC 101	1.27	4.65	14.84	14.19
GC 1601	1.16	4.57	14.17	13.52
PGCP 24	1.06	4.45	13.46	12.37
HC 46	1.12	4.54	14.30	13.31
SE(m)±	0.03	0.04	0.16	0.35
CD (P=0.05)	0.09	0.13	0.46	1.03

Table 2: Effect of irrigation scheduling on LAI of cowpea varieties

Treatments	At 30 DAS	At 45 DAS	At 60 DAS	At harvest
Irrigation schedules				
Irrigation at 7 days interval	0.31	2.41	7.16	9.75
Irrigation at 11 days interval	0.25	2.08	5.77	8.42
Irrigation at 15 days interval	0.23	1.94	5.16	7.94
SE(m)±	0.01	0.02	0.05	0.07
CD (P=0.05)	0.01	0.08	0.22	0.28
Varieties				
RC 101	0.27	2.28	6.44	9.20
GC 1601	0.26	2.21	6.06	8.80
PGCP 24	0.25	1.93	5.59	8.13
HC 46	0.25	2.16	6.03	8.69
SE(m)±	0.01	0.01	0.03	0.05
CD (P=0.05)	0.02	0.04	0.08	0.16

Water Use Efficiency

Data presented in Table 3 showed the effect of irrigation scheduling on water use efficiency of cowpea varieties. The table depicted that water use efficiency was significantly affected by different irrigation schedules. The maximum water use efficiency of 34.93 kg/ha-cm was recorded with irrigation scheduling at 15 days interval which was significantly highest than 11.99 and 25.83 kg/ha-cm irrigation at 7 and 11 days interval, respectively. Water use efficiency under irrigation scheduling at 7 days interval was less because of lower seed yield but irrigation water applied was highest. While it was more in 15 days interval irrigation scheduling due to non-significant difference in yield as compare to 11 days interval but water application was lower. Probative findings were also reported by Kumar and Pareek (2022) [13].

Varieties also differ significantly in water use efficiency. The highest water use efficiency of 27.20 kg/ha-cm was observed in variety GC 1601 which was at par with variety PGCP 24 with value of26.55 kg/ha-cm. Lowest value of water use efficiency was recorded in variety HC 46 that was 20.69 kg/ha-cm and it was at par with variety RC 101 with value 21.86 kg/ha-cm. Difference in water use efficiency was due to tendency of different varieties to utilize applied water in terms of seed yield.

Table 3: Effect of irrigation scheduling on water use efficiency (kg/ha-cm) of cowpea varieties

Treatments	Water use efficiency
Irrigation schedules	
Irrigation at 7 days interval	11.99
Irrigation at 11 days interval	25.83
Irrigation at 15 days interval	34.93
SE(m)±	0.34
CD (P=0.05)	1.44
Varieties	
RC 101	21.86
GC 1601	27.20
PGCP 24	26.55
HC 46	20.69
SE(m)±	0.44
CD (P=0.05)	1.31

Yield and economics

Seed yield showed a greater variation from 660 to 904 kg/ha under different irrigation scheduling interval from Table 4. Highest seed yield of 904 kg/ha was fetched when we apply irrigation at 11 days interval which was 3.6% and 36% higher than yield recorded under 15 and 7 days interval, respectively. Possible reason to get lowest yield under 7 days interval irrigation scheduling was continues vegetative growth of crop for longer time due to excess availability of moisture but under irrigation schedules at 11 and 15 days interval plant have optimum growth for utilizing available resources toward seed formation through optimum photosynthesis. Corroborative results were also observed by Kumar *et al.* (2015) [12].

It can be clearly depicted that irrigation scheduling have significant effect on economics of cowpea varieties. Highest cost of cultivation of 35790 ₹ ha^{-1} was recorded with irrigation at 7 days interval, followed by irrigation at 11 and 15 days interval with cost of cultivation of 31790 ₹ ha^{-1} and 29790 ₹ ha^{-1}. While irrigation scheduling at 11 days interval fetched highest gross returns and net returns of 59369 ₹ ha^{-1} and 29579 ₹ ha^{-1}, respectively, followed by irrigation at 15 days interval with values 57657 ₹ ha^{-1} and 25867 ₹ ha^{-1} respectively. Whereas maximum BC ratio was calculated in 15 days irrigation interval 1.93, followed by 1.87 at 11 days irrigation interval. The lowest gross returns, net returns and BC ratio of, 45402 ₹ ha^{-1}, 9612 ₹ $ha^{-1}$and 1.27, respectively, was fetched with irrigation scheduling at 7 days interval.

Among varieties seed yield ranged from 682 to 937 kg/ha. Seed yield of variety GC 1601 was 4.1, 28.5 and 37.4% more as compared to variety PGCP 24, RC 101 and HC 46. Yield variation in variety was greatly depended on their yield potential and their tendency to utilize resources. In varieties cost of cultivation was almost same. Variety GC 1601 fetched maximum gross returns, net returns and BC ratio of 61809 ₹ ha^{-1}, 29353 ₹ ha^{-1} and 1.93, followed by variety PGCP 24 (58779 ₹ ha^{-1}, 26323 ₹ ha^{-1} & 1.83) and RC 101 (49920 ₹ ha^{-1}, 17464 ₹ ha^{-1} & 1.56) with respective values of gross returns, net returns and BC ratio. Minimum gross returns, net returns and BC ratio of (46063 ₹ ha^{-1}, 13606 ₹ ha^{-1} & 1.45) was recorded in variety HC 46.

Table 4: Yield and economics of different treatments as affected by irrigation scheduling and cowpea varieties

Treatments	Seed yield (kg/ha)	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC Ratio
Irrigation schedules					
Irrigation at 7 days interval	660	35790	45402	9612	1.27
Irrigation at 11 days interval	904	31790	59369	29579	1.87
Irrigation at 15 days interval	873	29790	57657	25867	1.93
SE(m)±	14	-	-	-	-
CD (P=0.05)	57	-	-	-	-
Varieties					
RC 101	730	32457	49920	17464	1.56
GC 1601	937	32457	61809	29353	1.93
PGCP 24	900	32457	58779	26323	1.83
HC 46	682	32457	46063	13606	1.45
SE(m)±	17	-	-	-	-
CD (P=0.05)	52	-	-	-	-

Conclusion

On the basis of experimentation it can be concluded that irrigation scheduling at 11 days interval has maximum seed yield and net returns but irrigation at 15 days interval has maximum benefits. Among varieties, GC 1601 is superior than other varieties having maximum seed yield, net returns and BC ratio.

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