Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 2444-2448
Received: 05-11-2017
Accepted: 06-12-2017

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Growth and yield of pulses as influenced by irrigation levels in southern dry zone of Karnataka

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Abstract
A field experiment was conducted on a sandy loam soil at college of Agriculture V. C. Farm Mandya, UAS Bengaluru in *kharif* 2016 to study the effect of irrigation levels on productivity of pulses in southern dry zone of Karnataka for achieving optimum irrigation schedule and higher yield. The experiment was laid out in Split-plot Design with four levels of irrigation as main plot *viz.*, irrigation at 60, 80, 100 per cent CPE (cumulative pan evaporation) and irrigation as per recommended irrigation practices in Southern Dry Zone of Karnataka. The pulses grown in Sub-plots were Greengram, Blackgram and Fieldbean. Analysis was done for crop equivalent yield. The results revealed that, higher growth and yield parameters of pulses *viz.*, plant height (23.48 to 32.44 per cent), leaf area (93.39 to 30.41 per cent), dry matter production (30.68 to 36.32 per cent), number of pod (21.33 to 23.73 per cent), pod length (9.06 to 12.75 per cent) and haulm yield (9.09 to 12.41 per cent) recorded with irrigation at 80% fallowed by irrigation at 100% CPE as compared to recommended practice. However reduction in growth and yield parameters of pulses at 60 % CPE irrigation level as compared to recommended practice. Significantly higher greengram equivalent yield recorded with irrigation at 80% CPE (1710 kg ha^{-1}) as compared to irrigation at 60 % CPE and recommended practice (1427 and 1502 kg ha^{-1}, respectively) but was on par with irrigation at 100% CPE (1619 kg ha^{-1}). The treatment combination of irrigation at 80 per cent CPE and blackgram recorded significantly higher greengram equivalent yield of 2201 kg ha^{-1} as compared to rest of the combinations. Hence scheduling irrigation at 80 per cent CPE in pulses enhances growth and yield in Southern Dry Zone of Karnataka.

Keywords: irrigation, pulses, growth, yield, CPE

Introduction
Pulses occupy a very significant place in Indian farming as they are the source of food, fodder and feed. They have ability to fix atmospheric nitrogen and play a very important role in sustaining soil productivity. Pulses are grown all over India and protein requirement of human being for growth and development is mostly met through pulses. Protein content in pulses ranges from 21-26 per cent, carbohydrates around 60 per cent and also a good source of vitamins like thiamin, riboflavin, niacin and ascorbic acid.

More than 85 per cent area under pulses depends on rainfall, while water is life of any crop (Prem Narayan and Sandeep Kumar, 2015) [12]. The area and production growth of pulses is slow due to low productivity of 411 kg ha^{-1} during 1950-51 and 688 kg ha^{-1} during 2010-11 over six decades; however the area under pulses 19.03 million ha during 1950-51 increased to 26.68 million ha only, as compared to food grain production (Prem Narayan and Sandeep Kumar, 2015) [12].

In view of rapid increase in population and day by day decrease in water resources and to fulfill the increasing pulse demand and decreasing pulse production; sustainable water management practices and estimation of water requirement will help to increase productivity of pulses, water productivity, water use efficiency and area of pulses under irrigation. Improving water use efficiency in agriculture will require an increase in crop water productivity i.e., an increase in marketable crop yield per unit of water used by plant and reduction in water losses from the crop root zone. Among the sustainable water management practices, scheduling irrigation based on evaporation is one of the best methods in semi arid condition where annual rainfall is low.

Crop water requirement is the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate regime, when adequate soil moisture maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield (Hess, 2005). The assessment of water needs of the crop based on day to day weather parameters seems to be more rational than any other method (Senthilkumar, 1990) [14]. In agricultural fields, large spatial variations in soil water content are associated with soil heterogeneities such as precipitation level, land cover, topography, evapotranspiration etc.

Scientific irrigation scheduling should go with an understanding of soil-water-plant-atmosphere continuum. Irrigation water economy can be aimed through appropriate irrigation schedules and meteorological approach based on pan evaporation is one of the simplest, reliable, economical and least time consuming methods (Prihar *et al*., 1976) [13]. Keeping this in view, the present investigation "Growth and yield of pulses as influenced by irrigation levels in Southern Dry Zone of Karnataka" was taken up during *kharif* 2016 at college of Agriculture, Vishweshwaraiah Canal Farm, Mandya.

Material and methods

A field experiment was conducted during kharif season of 2016 at Collage of Agriculture, Vishweshwaraiah Canal Farm, Mandya (Karnataka) to study the performance of pulses with irrigation levels in southern dry zone of Karnataka. The experiment was laid out in split plot design with four irrigation levels *viz.*, irrigation at 60 % (I_1), 80 % (I_2), 100 % (I_3) of cumulative pan evaporation (CPE) and recommended irrigation practice in southern dry zone of Karnataka (I_4) as main plot and three pulses *viz.*, P_1: greengram (KKM-3), P_2: blackgram (Rashmi) and P_3: fieldbean (HA-4) as sub plot with three replications. The soil of experimental site is red sandy loam with neutral soil pH (7.6), organic carbon content was medium (0.66 percent) with an electrical conductivity (EC) of 0.18 dSm^{-1}, medium in available nitrogen (275.96 kg/ha), phosphorus (30.77 kg/ha) and potassium (201.26 kg/ ha). The pulses were planted on 16 July 2010 with common row spacing of 30 and 10 cm between plants. Equal quantity of farm yard manure at the rate of 5 t/ha was applied to each plot three weeks prior to planting. The recommended doses of 25 kg of nitrogen, 50 kg P_2O_5 and 25 kg K_2O per ha were applied uniformly as basal dose at the time of planting in the form of urea, single super phosphate and muriate of potash, respectively. One general irrigation at 5 cm depth was given to all plots after sowing to ensure uniform germination and crop establishment and counted the applied water through water meter. The required quantity of water per plot based on 60%, 80% and 100% cumulative pan evaporation was calculated by using USWB open pan evaporimeter. For recommended irrigation practice water was applied @ 5 cm depth. For measuring the water to be applied for each treatments water meter was used. Measured quantity of water (liter $plot^{-1}$) was applied through surface irrigation at an interval of 8 days. Three irrigation levels *viz.*, 60, 80 and 100 per cent CPE were compared with recommended irrigation practice (5cm). the growth parameters like plant height, leaf area and total dry matter production recorded at harvest and yield parameters like number of pod per plant, pod length, haulm and grain yield was recorded. Due to different morphological characters of the pulses taken for study, the comparison was made on per cent increase or decrease in growth and yield parameters. The grain yield was converted in to greengram equivalent yield of blackgram and fieldbean and statistically analysed using Fisher's method of analysis of variance technique as given by Panse and Sukhatme (1967) [9].

Results and Discussion

Growth parameters

Growth parameters of greengram, blackgram and fieldbean as influenced by irrigation levels at harvest are presented in graph 1 to 3. Scheduling irrigation with 80 per cent CPE resulted the highest increase in growth parameters *viz.*, plant height, leaf area and dry matter production at harvest in all pulses *viz.*, greengram (27.39, 9.39 and 33.86 per cent, respectively), blackgram (32.44, 30.41 and 36.32 per cent, respectively) and fieldbean (23.48, 20.47 and 30.68 per cent, respectively) over recommended irrigation practice. Fallowed by irrigation at 100 per cent CPE (15.13, 5.04 and 20.38 per cent, respectively) in greengram, (23.7, 20.19 and 22.37 per cent, respectively) in blackgram and (16.98, 12.47 and 22.73 per cent, respectively) in fieldbean. However, decrease in the growth parameters *viz.*, plant height, leaf area and dry matter production at harvest in all pulses *viz.*, greengram (13.84, 4.09 and 13.9 per cent, respectively), blackgram (9.52, 8.82 and 6.08 per cent, respectively) and fieldbean (11.49, 10.18 and 9.93per cent, respectively) over recommended irrigation practice recorded in the irrigation level on 60 per cent CPE.

Patel *et al.* (2014) [10] have also reported that irrigation scheduling at 0.8 IW/CPE ratio recorded significantly higher plant height (49.78 cm) and number of branches $plant^{-1}$ (3.44) in greengram. These results are in agreement with the findings of Patel *et al.* (2009) [11], Behera *et al.* (2015) [1] and Kumbhar *et al.* (2015) [8].

These higher growth parameters in irrigation level at 80 per cent CPE at harvest might be attributed due to adequate supply of moisture, which favorably improve better availability of nutrients throughout the crop growth and improve nutrient uptake and translocation of nutrient which ultimately linked with growth and development (Dutta *et al.* 2015) [4]. All these lead to higher initial growth attributes *viz.*, taller plant and thereby more leaf area per plant and dry matter production at the harvest (Fig. 1 to 3).

The lower growth parameters with irrigation level at 60 per cent CPE might be due to unsaturated soil moisture environment and vapour gap around the roots by their turgor pressure under water stress. Such a gap if ever present would reduce the availability of nutrients to the roots probably due to lesser contact between roots and water particle causing drastic reduction in dry matter production and uptake of nutrients (Patel *et al*. 2014) [10].

This may be the major reason for lower yield of crop with moisture stress with irrigation level at 60 per cent CPE, while in case of recommended practice (5 cm) might be due to reduced oxygen concentration in wet soil which causes stomatal closure of plant leads to reduction in transpiration although water is available (Suat and William, 2008) [17].

Solanki *et al.* (2012) [16] have also observed that scheduling irrigation at 0.8 IW/CPE ratio maintained optimum soil moisture condition throughout the crop growth period and higher nutrient uptake. These results are also in agreement with the findings of Singh *et al.* (2003) [15], Patel *et al.* (2009) [11], Patel *et al*. (2014) [10], Chavan *et al*. (2014) [3], Behra *et al.* (2015), Kapil *et al.* (2015) [6] and Yogesh Kumar *et al.* (2016) [18].

Yield parameters

Yield parameters of greengram, blackgram and fieldbean as influenced by irrigation levels are presented in graph 4 to 6. Scheduling irrigation with 80 per cent CPE resulted the highest increase in yield parameters *viz.*, number of pod $plant^{-1}$, pod length and haulm yield in all pulses *viz.*, greengram (22.73, 12.75 and 12.41 per cent, respectively), blackgram (22.92, 6.99 and 10.44 per cent, respectively) and fieldbean (21.33, 9.06 and 9.09 per cent, respectively) over recommended irrigation practice. Fallowed by irrigation at 100 per cent CPE (15.52, 6.99 and 5.49 per cent, respectively) in greengram, (16.02, 7.92 and 4.47 per cent, respectively) in blackgram and (13.5, 4.81 and 5.21 per cent, respectively) in fieldbean. However, decrease in the yield parameters *viz.*, number of pod plant^{-1}, pod length and haulm yield in all pulses *viz.*, greengram (6.27, 7.51 and 6.15 per cent, respectively), blackgram (8.33, 4.59 and 3.18 per cent, respectively) and fieldbean (7.37, 3.68 and 2.6 per cent, respectively) over recommended irrigation practice recorded in the irrigation level on 60 per cent CPE.

These results are also in agreement with the findings of Singh *et al.* (2003) [15] and Patel *et al.* (2009) [11] where number of pod plant^{-1}, number of seed pod^{-1} and grain yield significantly higher with irrigation scheduled at IW/CPE ratio 0.8. Patel *et al.* (2014) [10] and Chavan *et al.* (2014) [3] also reported that significantly higher straw yield of greengram was recorded with irrigation level 0.8 IW/CPE ratio. These results are also in agreement with the findings of Patel *et al.* (2009) [11], Patel *et al.* (2014) [10], Behera *et al.* (2015) [1], Dutta *et al.* (2015) [4] and Kumbhar *et al.* (2015) [8].

These higher grain yield and yield parameters in irrigation level at 80 per cent CPE might be attributed to its key role in root development by mechanical resistance leading to greater nutrient uptake and higher transpiration resulted in more photosynthesis (Solanki *et al.* 2012) [16]. Another reason may be due to maintenance of optimum soil moisture condition which affected the root nodulation as well as availability of different nutrients, further adequate availability of moisture at all stages of crop growth and development lead to high water potential, stomatal conductance, higher photosynthesis, partioning of photosynthates to sink consequently increasing dry matter production and ultimately increased yield parameters and yield (Chaudhary *et al.*, 2014) [2]. Scheduling irrigation at 0.8 IW/CPE ratio maintained optimum soil moisture condition throughout the crop growth period as observed by Kapil *et al.*, 2015 [6].

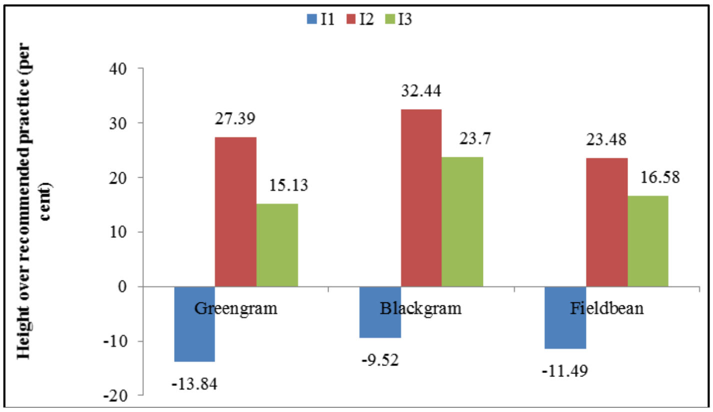
These results are also in agreement with the findings of Solanki *et al.* (2012) [16], Chaudhary *et al.* (2014) [2], Kumar *et al.* (2015), Dutta *et al.* (2015) [4] and Yogesh Kumar *et al.* (2016) [18].

Equivalent yield

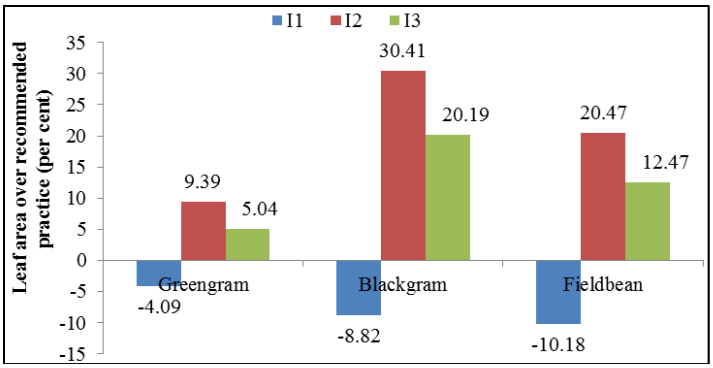
The data recorded on grain yield of greengram, blackgram and fieldbean (Table 1) as influenced by irrigation levels was converted in to greengram equivalent yield and presented in Table 2. Irrigation at 80 per cent CPE resulted in significantly higher greengram equivalent yield 1710 kg ha^{-1}, and which was 13.84 per cent higher than the yields obtained with recommended irrigation practice (1502 kg ha^{-1}) respectively, but it was on par with Irrigation at 100 per cent CPE (1619 kg ha^{-1}). However, the lowest yield was recorded with irrigation at 60 per cent CPE (1427 kg ha^{-1}).

The treatment combinations of irrigation levels and pulses showed significant difference in greengram equivalent yield. Scheduling irrigation at 80 per cent CPE with blackgram recorded the highest greengram equivalent yield (I_2P_2: 2201 kg ha^{-1}) followed by (I_3P_2: 2084 kg ha^{-1}) as compared to all other combinations.

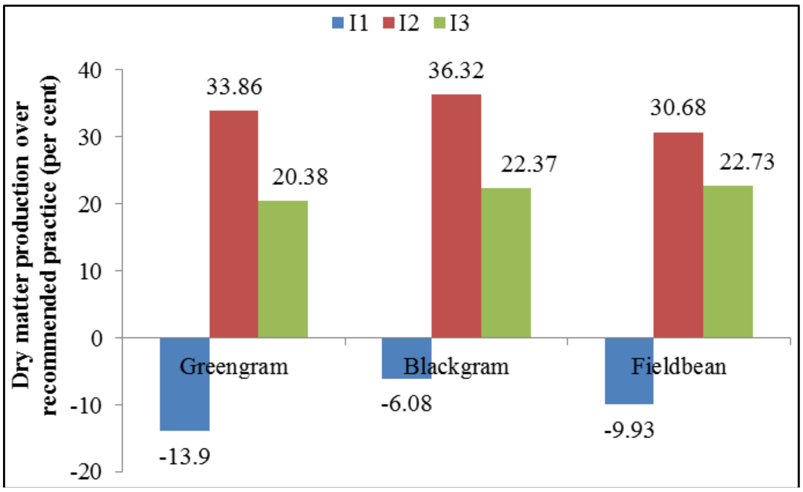
Patel *et al.* (2009) [11] revealed that irrigation scheduling at 0.8 IW/CPE ratio significantly increased the seed yield of chick pea (1156 kg ha^{-1}) respectively, as compared to irrigation schedules IW/CPE ratio 1.0, 0.6 and 0.4. These higher grain yield and yield parameters in irrigation level at 80 per cent CPE might be attributed to its key role in root development by mechanical resistance leads to greater nutrient uptake and higher transpiration resulted in more photosynthesis (Solanki *et al.* 2012) [16].



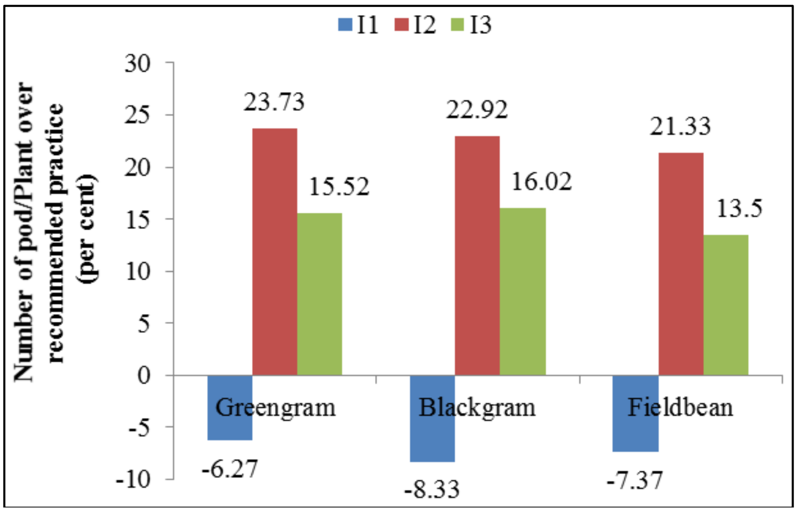
Graph 1: Per cent height of pulses over recommended irrigation practice



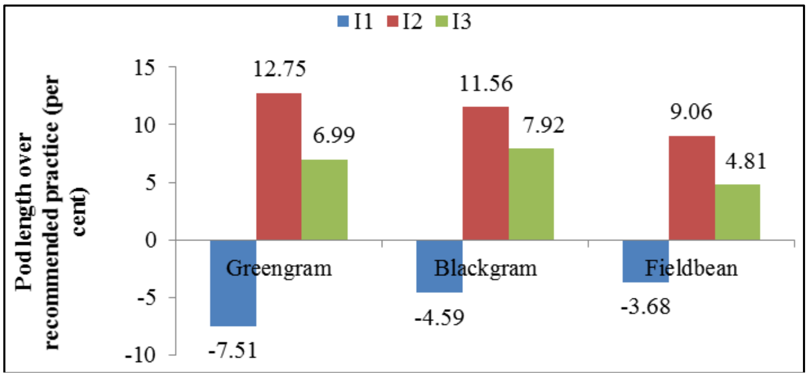
Graph 2: Per cent leaf area of pulses over recommended irrigation practice



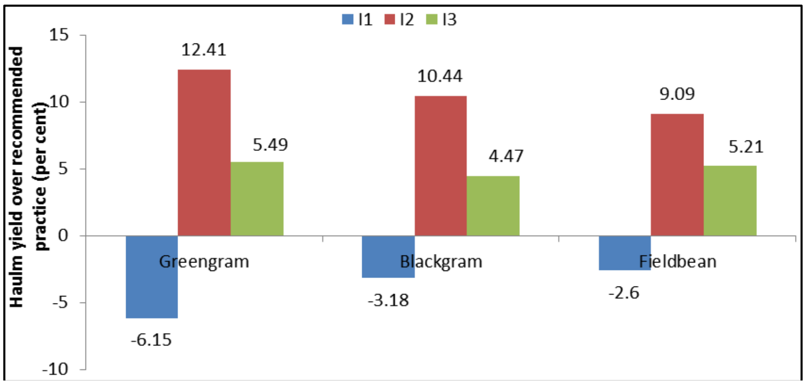
Graph 3: Per cent leaf area of pulses over recommended irrigation practice



Graph 4: Per cent number pod of pulses over recommended irrigation practice



Graph 5: Per cent pod length of pulses over recommended irrigation practice



Graph 6: Per cent haulm yield of pulses over recommended irrigation practice

Table 1: Grain yield (kg ha^{-1}) of greengram, blackgram and fieldbean is influenced by irrigation levels

Treatments	Greengram	Blackgram	Fieldbean
I_1	770	1036	1176
I_2	956	1222	1332
I_3	900	1161	1272
I_4	824	1066	1222

I_1: Irrigation at 60% CPE
I_2: Irrigation at 80% CPE
I_3: Irrigation at 100% CPE
I_4: Irrigation as per recommended practice in southern dry zone of Karnataka

Table 2: Greengram equivalent yield (Kg ha^{-1}) of blackgram and fieldbean and water use efficiency (Kg ha-cm^{-1}) as influenced by irrigation levels

	Greengram equivalent yield (Kg ha^{-1})			
	P_1	P_2	P_3	Mean
I_1	770	1826	1685	1427
I_2	956	2201	1974	1710
I_3	900	2084	1872	1619
I_4	824	1907	1775	1502
Mean	863	2004	1826	
	S.Em±		CD @ 5%	
Irrigation Levels	52.44		180.42	
Interaction	13.71		40.97	

I_1: Irrigation at 60% CPE
I_2: Irrigation at 80% CPE
I_3: Irrigation at 100% CPE
I_4: Irrigation as per recommended practice in southern dry zone of Karnataka

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