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Seed yield, consumptive use of water, water use efficiencyand moisture extraction pattern of summer moth bean as influenced by dates of sowing and irrigation scheduling (IW:CPE ratio)

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Abstract
A field experiment was conducted during summer season of the year 2010 at Anand Agricultural University, Anand, Gujarat. To study the influence of dates of sowing and irrigation scheduling (IW:CPE ratio) on Yield attributes and yield of summer moth bean. Date of sowing had significant effect on seed yield of moth bean. Significantly the highest seed (460 kg/ha) was recorded under treatment D_2 (sowing at 30th January). Whereas, significantly lower seed (368 kg/ha) was under treatment D_1 (sowing at 20th January).
Treatment I_2 (0.7 IW:CPE ratio) secured significantly the highest seed (472 kg/ha), whereas, significantly the lowest seed (319 kg/ha) was observed under treatment I_0 (control, irrigation at critical growth stages). The results indicated that the different levels of date of sowing did not influenced on consumptive use of water. The highest consumptive use of water (558.3mm) was recorded under treatment I_3 (0.9 IW:CPE ratio), followed by I_2 (0.7 IW:CPE ratio), I_1 (0.5 IW:CPE ratio) and I_0 (control – irrigation at critical growth stages).Treatment D_2 (sowing at 30th January) recorded higher water use efficiency (1.17 kg/ha - mm). While the lowest water use efficiency (0.97 kg/ha-mm) was recorded under treatment D_1 (sowing at 20th January).The highest water use efficiency (1.27 kg/ha-mm) was recorded under treatment I_0 Control (Irrigation at critical growth stages), followed by treatment I_1 (0.5 IW:CPE ratio) and I_2 : (0.7 IW:CPE ratio). The maximum percent of moisture was extracted from 0-15 cm soil depth, followed by 15-30 cm soil depth for all the treatments of irrigation (IW:CPE ratio).

Keywords: Date of sowing, irrigation scheduling, water use efficiency, consumptive use, moisture extraction and summer Mothbean

Introduction
Moth bean (*Vigna contifolia* (Jacq.) Marechal) originated in the semi-arid regions of India, most probably in the State of Rajasthan (Fageria, 1992) [3]. It is cultivated in the states of Rajasthan, Haryana, Utter Pradesh, Punjab, Maharashtra, and Gujarat. The most common sowing practice was through broadcast. In Punjab, it was cultivated with black and green grams as a mixed crop, more often in the unfertile soils. It is a ground-hugging plant and only about a one foot high. The crop is generally grown in the north Western deserts regions of India and Pakistan, especially In area where moong bean greatly suffers from drought. The lower productivity of this crop is attributed to several factors such as growing under moisture stress conditions, marginal lands with very low inputs and without pest and disease management, non avaibility of high yielding varieties and late sowing. Moreover, the yield of local cultivars of moth been is much less as compared to other pulse crops. Hence, there is need to enhance the production potential of this crop through use of organic manures, biofertilizers. Chemical fertilizers play an important role to meet the nutrient requirement of the crop but continuous use of these on lands will have deleterious effects on physical chemical and biological properties of soil, which in turn reflects on yield (Sarkar *et al.*,1992) [9].
Date of Sowing has been recognized as the most important non-monetary input affecting yield of *summer* moth bean as late sowing coincides with high temperature during the initial crop growth stage and pre- monsoon shower at reproductive stage. On the other hand, early sown crop faces moderate temperature during initial growth stage, particularly in middle Gujarat region, which adversely affect the crop growth and finally the yield. Late sowing does not provide enough time to prepare land for *kharif* crop, which delays *kharif* sowing. Therefore, it

Therefore, it it is imperative to determine the optimum time of sowing of moth bean crop for obtaining higher economic yield. Water is well known essential constituent of living organism for their growth and development. Both excess or deficit use of water, reduces the crop yield drastically. Water stress during the active crop growth phase results into cessation of growth as it influences the photosynthesis and other physiochemical processes and or death, by desiccation. The excess water leads to the problems of raising water table, soil salinity. Hence, water management studies have become an important aspect of research for irrigated crops. Irrigation is mainly given to crop for achieving maximum yield with batter quality of produce. The ideal scheduling of irrigation depends upon the soil, climate and plant characteristics. Keeping all these factors in view, the present research work entitled “Influence of date of sowing and irrigation scheduling (IW:CPE ratios) on growth, yield attributes and yield of summer moth bean under middle Gujarat conditions.

Materials and Methods

The present experiment was conducted at Agronomy Farm of Anand Agricultural University, Anand, (Gujarat) during summer season of the year 2010. The climate of this region is semi-arid and sub-tropical with an average rainfall of 870 mm received entirely from the south west monsoon current. The mean minimum temperature ranged from 12.2 ºC to 23.7 ºC and mean maximum temperature ranged from 30.3 ºC to 41.7 ºC during the crop season of the year 2010. The data regarding daily pan evaporation measured from USWB class ‘A’ pan evaporimeter during the experimental period. Total quantity of water applied were 250, 350, 450 and 550 mm with the depth of water of 50 mm under irrigation scheduling I_0 Control (Irrigation at critical growth stages), I_1 0.5 IW:CPE ratio, I_2 0.7 IW:CPE ratio and I_3 0.9 IW:CPE ratio. The detail of experimental techniques employed for the investigation was stripe plot consisted four date of sowing i.e. D_1 = 20th January, D_2 = 30th January, D_3= 9th February and D_4=19th February as first stripe and four irrigation scheduling levels i.e. I_0 – critical growth stages @ Branching, at flowering, at pod formation, at grain formation. (Control), I_1 – 0.5 IW: CPE ratio, I_2 - 0.7 IW: CPE ratio and I_3 - 0.9 IW: CPE ratio.

The crop was fertilized with 20 kg N and 40 kg P_2O_5 per hectare from DAP and urea as basal application i.e. before sowing in opened furrow as common application.Pods were harvested manually when they turned brown to dark brown. The pods from border lines were harvested first and kept separately. Then, the pods from net plot were manually picked and allowed to sun dry for four days in cotton bags. The seed weight of each net plot was done by pan balance and recorded for each net plot separately. Five randomly selected and tagged plants from each plot were used for recording observation on yield attributes.

Soil Moisture Studies

Soil moisture studies in the present experiment comprised of consumptive use of water (mm), water use efficiency (yield in kg/ mm of water used), and moisture extraction pattern.

Consumptive use of water

The consumptive use of water under different treatments was computed by using the following formula as described by Mishra and Ahmad (1987) [4].

CU of water (mm) = (E_0 × 0.6) + Profile soil moisture + Effective rainfall + Ground water contribution.

Water use efficiency (kg/ha-mm)

The response of seed yield per unit of irrigation water used at varying level of irrigation was worked out by dividing per hectare seed yield of moth bean crop obtained under various treatment with the total consumptive use of water (mm) of the respective treatment and it was recorded as water use efficiency which was worked out by the followed formula which is described by Patel (1993).

$$\text{WUE (Kg/ha-mm)} = \frac{\text{Seed yield (kg/ha)}}{\text{Total consumptive use of water (mm)}}$$

Moisture extraction pattern

The soil moisture extraction pattern is the relative amount of moisture extracted from different soil depths within the crop root zone. Samples from four different soil depths viz, 0-15, 15-30, 30-45 and 45-60 cm soil depth were taken to determine to the moisture extraction pattern and the sum was expressed in the percentage of total water used.

The data generated on yield, and various characterized were subjected to statistical analysis using “Analysis of variance technique”. The value of table ‘F at 5% level of significance, where the treatment differences were found significant the value of CD and C.V. %were also worked out to compare the treatment mean (Snedecor and Cochran, 1967) [10].

Result and Discussion

Influence of date of sowing and irrigation scheduling (IW:CPE ratio) on seed yield

Date of sowing had significant effect on seed yield of moth bean (Table 1). Significantly the highest seed yield (460 kg/ha) was recorded under treatment D_2 (sowing at 30th January). Whereas, significantly lower seed yield (368 kg/ha) was under treatment D_1 (sowing at 20th January), being at par with treatments D_4 (sowing at 19th February), D_3 (sowing at 9th February), respectively. Treatment D_3 (sowing at 9th February) and Treatment D_4 (sowing at 19th February) were remained at par with each other. Treatment D_2 (sowing at 30th January) recorded higher seed yield to the tune of 18.26%, 19.78% and 20% over the treatments D_3(sowing at 9th February), D_4 (sowing at 19th February) and D_1 (sowing at 20th January), respectively. Significantly the highest seed yield (472 kg/ha) was observed under treatment I_2 (0.7 IW:CPE ratio), whereas significantly the lowest seed yield (319 kg/ha) was observed by treatment I_0 (control, irrigation at critical growth stages). Treatment I_1 (0.5 IW:CPE ratio) was remained at par with treatment I_3 (0.9 IW:CPE ratio). Treatment I_2 (0.7 IW:CPE ratio) recorded higher seed yield at the extant of 16.73%, 17.58%, and 32.41% over the treatments I_1 (0.5 IW:CPE ratio), I_3 (0.9 IW:CPE ratio) and I_0 (control, irrigation at critical growth stages), respectively.

The reduction in yield due to delay in sowing might be attributed to less flowering and pod setting on account of unfavourable temperature accompanied by hot winds coinciding with flowering and pod setting stage of the late sown crop and consequence of high insect flower and pod borer infection occurred due to high air temperature. When the mean temperature was 24 ^{0}C all the cultivars of legume crop flowered, however, cultivars failed to flower at mean temperature of 33 ^{0}C. Since the mean temperature varied from 20 ^{0}C to more than 33 ^{0}C during the crop growth period might be responsible for reduction in seed yield with delayed sowing. Rowson and craven (1972) [7] and Sahu (1986) [8] have also reported marked reduction in seed yield of black gram due to delay sowing.

In context to environmental condition, scheduling irrigation at 0.7 IW:CPE ratio provided with the optimum reproductive phase with larger photosynthetic green surface and reproductive storage capacity to attain higher allocation of dry matter to seed in moth bean. The results are supported by Vasimalai and Subramaniam (1980) [13].

Influence of date of sowing and irrigation scheduling (IW:CPE ratio) on Consumptive use of Water.

The results indicated in Table 2 and graphically depicted in Fig 1.that the different levels of date of sowing did not influenced on consumptive use of water. It was indicated that consumptive use of water was uniform. the mean consumptive use of water was influenced due to different irrigation schedules. The highest consumptive use of water (558.3mm) was recorded under treatment I_3 (0.9 IW:CPE ratio), followed by I_2 (0.7 IW:CPE ratio), I_1 (0.5 IW:CPE ratio) and I_0 (control – irrigation at critical growth stages). In general, the consumptive use of water increased with the increase in the quantity of irrigation water.This might be due to more number of irrigations with high quantity of water increased the consumptive of water, due to better growth of crop and simultaneously the loss of water through evaporation owing to availability of wet regimes for longer period under latter scheduling. Inadequate moisture supply to the crop under $I_{0:}$ Control (Irrigation at critical growth stages) treatment resulted in lower CUW. These findings are analogous to those reported by and Soni and Gupta (1999) [11] for green gram. Other reason might be due to conductive effect of wet rhizosphere on maintenance of wet surface for longer period and consequently had led to higher losses through evaporation. Moreover, creation of higher vapour pressure gradient between canopy air and atmospheric air might be responsible for greater evapotranspiration from frequently irrigated plots. Patel *et al.* (2008) [5].

Influence of date of sowing and irrigation scheduling (IW:CPE ratio) on Water use efficiency.

From the dataTable-2 and graphically depicted in Fig 1, the results revealed that the mean water use efficiency was influenced due to different date of sowing. Treatment D_2 (sowing at 30th January) recorded higher water use efficiency (1.17 kg/ha -mm). While the lowest water use efficiency (0.97 kg/ha-mm) was recorded under treatment D_1 (sowing at 20th January).

The data revealed that the mean water use efficiency was influenced due to irrigation scheduling (IW:CPE ratio). The highest water use efficiency (1.27 kg/ha-mm) was recorded under treatment I_0 Control (Irrigation at critical growth stages), followed by treatment I_1 (0.5 IW:CPE ratio) and $I_{2:}$ (0.7 IW:CPE ratio). While the lowest water use efficiency (0.70 kg/ha-mm) was recorded under treatment I_3 (0.9 IW:CPE ratio).

The probable reason might be due to irrigation scheduling (IW:CPE ratio) influenced the water status of the soil profile, evapotranspiration and water use efficiency. An increase in frequency of irrigation resulted in higher soil moisture content and greater ET. Frequent wetting of the upper soil layer exposed to the hot atmosphere under 0.9 IW:CPE ratio created a higher vapour pressure gradiant between the crop canopy and the atmosphere, which might have caused relatively larger loss of water from the soil surface than in other schedules which resulted in lower water use efficiency. Soni and Gupta (1999) [11] and Dabhi *et al.* (2000) [2]. The higher WUE under control treatment- critical growth stages was stemmed from less water loss due to evapotranspiration under limited water supply were observed by Tank *et al.* (1996) [12], Bhadoria and Bhadoria (2002) for green gram.

Influence of date of sowing and irrigation scheduling (IW:CPE ratio) on moisture extraction pattern.

Moisture extraction pattern showed (Table-3) that the soil moisture extraction decreased progressively with depth of soil under all irrigation schedules (IW:CPE ratio). The moisture extracted from 0-15, 15-30, 30-45, and 45-60 cm of soil depth were 24.25, 19.40, 17.59 and 15.43 percent under treatment I_0 (control, irrigation at critical growth stages), 25.75, 19.00, 17.81 and 15.84 percent under treatment I_1 (0.5 IW:CPE ratio), 28.48, 20.20, 16.12 and 15.23 percent under treatment I_2 (0.7 IW:CPE ratio), 31.71, 21.50, 18.22 and 13.47 percent under treatment I_3 (0.9 IW:CPE ratio). The maximum percent of moisture was extracted from 0-15 cm soil depth, followed by 15-30 cm soil depth for all the treatments of irrigation (IW:CPE ratio). The moisture extraction increased with increase in quantity of irrigation water from upper soil layers (0-15 and 15-30 cm soil depth), where as, almost reverse trend was observed with respect to deeper soil layers (30-45 and 45-60 cm soil depth) under the study.

This might be due to the moisture extraction was increased with increase in frequency of the irrigation from upper soil layer and on the other hand, moisture extraction increased gradually with decrease in frequency of irrigation in deeper soil layer. Other reason might be due to the moisture extraction pattern under control (irrigation at critical growth stages) I_0 was relatively higher from the lower soil depth indicating higher activity of roots in the deeper soil layers under water stress. Moisture extraction increased with increase in the frequency of irrigation under first 0-30 cm soil depth, perhaps due to increase in the surface evaporation and water use. These findings are analogous to those reported by dewangan *et al.* (1993) and patel *et al.* (2008) [5].

Table 1: Effect of date of sowing and irrigation scheduling on seed yield

Treatments	Seed yield (Kg ha^{-1})
A Vertical strip (Date of sowing) (D)	
D_1 : 20th January	368
D_2 : 30th January	460
D_3 : 9th February	376
D_4 : 19th February	369
S.Em. ±	8.00
C.D. at 5%	25
B Horizontal strip (Irrigation IW:CPE ratios) (I)	
I0 : Control	319
I1 : 0.5 IW:CPE ratio	393
I2 : 0.7 IW:CPE ratio	472
I3 : 0.9 IW:CPE ratio	389
S.Em. ±	13
C.D. at 5%	41

Table 2: Effect of date of sowing and irrigation scheduling (IW:CPE ratios) on Consumptive use of water (mm) and water use efficiency (kg/ha-mm)

Treatments	Mean Consumptive use of water	Mean WUE
A Vertical strip (Date of sowing) (D)		
D_1 : 20th January	402.4	0.97
D_2 : 30th January	408.5	1.17
D_3 : 9th February	402.0	1.00
D_4 : 19th February	402.4	0.98
B Horizontal strip (Irrigation IW:CPE ratios) (I)		
I_0 : Control (Irrigation at critical growth stages)	250.8	1.27
I_1 : 0.5 IW:CPE ratio	353.7	1.12
I_2 : 0.7 IW:CPE ratio	452.5	1.04
I_3 : 0.9 IW:CPE ratio	558.3	0.70

Table 3: Effect of date of sowing and irrigation scheduling (IW:CPE ratios) on moisture extraction pattern

Treatment	Soil depth (cm)			
	0-15	**15-30**	**30-45**	**45-60**
A Vertical strip (Date of sowing) (D)				
D_1 : 20th January	21.69	19.46	16.59	15.58
D_2 : 30th January	21.25	18.78	16.46	14.98
D_3 : 9th February	19.84	17.13	15.21	13.29
D_4 : 19th February	18.05	16.68	14.55	11.23
B Horizontal strip (Irrigation IW:CPE ratios) (I)				
I_0 : Control (Irrigation at critical growth stages)	24.25	19.40	17.59	15.43
I_1 : 0.5 IW:CPE ratio	25.75	19.00	17.81	15.84
I_2 : 0.7 IW:CPE ratio	28.48	20.20	16.12	15.23
I_3 : 0.9 IW:CPE ratio	31.71	21.50	18.22	13.47

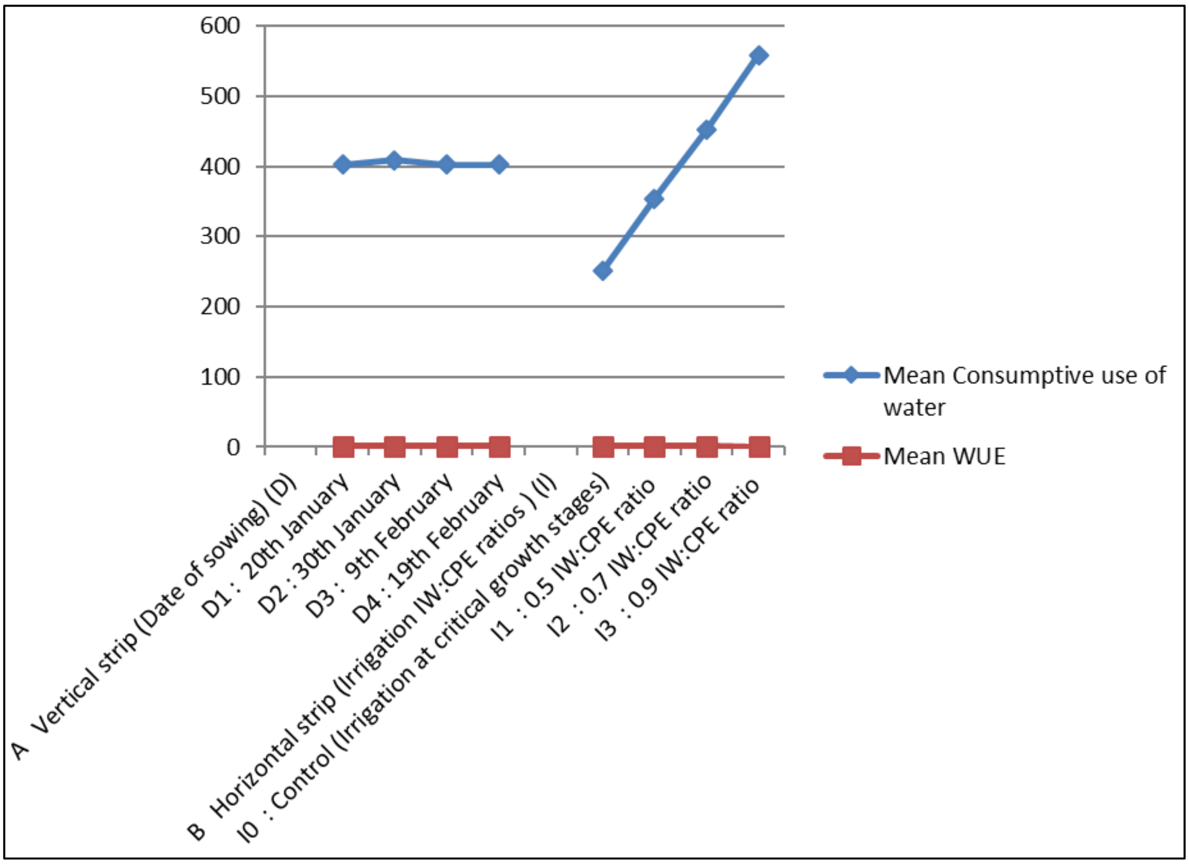

Fig 1: Effect of date of sowing and irrigation scheduling (IW:CPE ratios) on Consumptive use of water (mm) and water use efficiency (kg/ha-mm)

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