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Effect of irrigation scheduling and nutrition on yield attributes, pod yield and economics of summer cowpea

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Abstract

A field experiment was conducted at the Agricultural Research Station, Ladol, Gujarat, India, on summer cowpea (Vigna unguiculata [L.] Walp.) to study the Effect of irrigation scheduling and nutrition on yield attributes, yield and economics. The experiment was laid out in split plot design with four replications during summer season (March to June), 2013-14, 2014-15 and 2015-16. The experiment consisted three irrigation treatments viz. IW/CPE ratio 0.8, 1.0 & 1.2 and three fertility levels namely, 100% RDF (25:50:00 NPK kg/ha), 100% RDF + Rhizobium + PSB and 75% RDF + Rhizobium + PSB. Among the different irrigation levels crop irrigated at 1.2 IW/CPE ratio recorded significantly higher pod numbers/plant (~51), pod weight/plant (206.9 g), length of pod (14.2 cm) and pod yield (10.79 t/ha) of cowpea as compared to IW/CPE ratio of 0.8. The increase in green pod yield of cowpea due the application of irrigation water at 1.2 IW/CPE ratio was 31% and 4% higher compared to crop irrigated at 0.8 IW/CPE ratio and 1.0 IW/CPE ratio, respectively. Cowpea fertilized with 100% RDF + Rhizobium + PSB produced the significantly higher yield of green pod (10.34 t/ha) over 100% RDF (25:50:00 NPK kg/ha) (9.06 t/ha) and remain at par with 75% RDF + Rhizobium + PSB (10.02 t/ha). The pod yield increased with the application of 100% RDF + Rhizobium + PSB was 14% and 3% higher as compared to 100% RDF and 75% RDF + Rhizobium + PSB, respectively. Cowpea irrigated at IW/CPE ratio of 1.0 and fertilized with 100% RDF + Rhizobium + PSB had resulted in highest net benefit: cost ratios of 2.74 and 2.70, respectively.

Key words: Cowpea, economics, irrigation levels, green pod yield.

Cowpea [*Vigna unguiculata* (L.) Walp] is commonly known as *lobia* in India and one of the important pulse crop grown for vegetable, grain, forage and green manuring (Meena *et al.*, 2015). The main important characteristics of this crop include a good protein quality with a high nutritional value, its nitrogen-fixing ability, and more drought- and heat-tolerant than most of its legume relatives. Green tender pods are used as vegetable; the vegetable cowpea pods contain 84.6% moisture, 4.3% protein, 8.0% carbohydrate, and 0.2% fat, it is also rich source of calcium, phosphorus and iron (Meena, 2014). In India, cowpea is grown as sole, inter-crop and mix-crop, and is estimated to be cultivated in almost half of 1.3 m ha of area occupied by Asian region. Other Asian countries are Sri Lanka, Bangladesh, Myanmar, Indonesia, China, Korea, Pakistan and Nepal. In Indian context, it is a minor pulse cultivated mainly in arid and semi arid tracts of Rajasthan, Karnataka, Kerala, Tamilnadu, Maharashtra and Gujarat (Anonymous, 2016).

In a research perspective, studies on cowpea are relatively scarce, despite its relevance to its resilience to stress in agriculture. Plant growth rate is dependent on the interaction of many complex processes, which are influenced by both genetic and environmental factors. Nutrients are required by plant in adequate quantities for metabolic regulation, production of new tissues as well as development. They are structural components of metabolic and protoplasm structure (Adelusi and Aileme, 2006). Cowpea is a more important legume in regions where water stress is the major constraint for its production (Santos, 2000). Water stress has been reported to be one of the factors limiting the productivity of cowpea, because it, not only effects the production of the grain, even as the whole process of growth of all organs of the plant and its metabolism. Several studied showed that cowpea water use could be reduced by withholding irrigation during the vegetative stage without affecting seed yield. This provides a useful opportunity for improving irrigation water use in areas where irrigation water is scarce. The effects of water and soil fertility on crop yield are complex; a plant is usually subject to large fluctuations in water availability. Various studies established the facts that water deficit in the soil decreases the nutrient availability to plants, and because of its role in both the plant and soil for growth and nutrient transport, they reiterate the importance of iterative diagnosis and correction of nutrient problem with scheduling of irrigation to maintain timely and adequate consumptive water use. Water and nutrients both are the most important inputs or components of any crop for their potential growth and development. Mismatch of crop requirement for water and nutrients severely affect its productivity. Considering these facts the experiment was conducted to develop the efficient irrigation scheduling and balanced fertilizer application in summer cowpea to maximize the crop yield and economic returns.

Materials and Methods

Field experiment was carried out at the Agricultural Research Station, Ladol, Gujarat, India during summer season (March to June), 2013-14, 2014-15 and 2015-16. The soil of the experimental site was low in Nitrogen, medium in Phosphorus and Potassium. The soil of experimental plot was sandy loam in texture having 7.6 *pH*. The experiment was conducted in split plot design (SPD) with four replications. The treatments consisted of three irrigation levels i.e. irrigation at IW/CPE ratio of 0.8, 1.0 and 1.2 were allotted in main plot, whereas three fertility levels *i.e.* 100% RDF (recommended dose of fertilizers) (25:50:00 NPK kg/ha), 100% RDF + *Rhizobium* + PSB (phosphorus solubilizing bacteria) and 75% RDF + *Rhizobium* + PSB were allotted in subplot. The cowpea variety "AVC-1" (Anand Vegetable Cowpea-1) was sown in the month of March using 20 kg seed/ha at 45 cm × 10 cm (row × plant) spacing. The gross and net plot size was 13.50 m^2 and 7.92 m^2, respectively. The crop was irrigated and fertilized according to the treatments. All other management practices were followed as per the standard practices recommended for cowpea. Five plants from each plot were selected randomly for recording the pods/plant, pod weight/plant (gm) and pod length (cm). After removing the border rows from all the sides of gross plot, the net plot pod yield was recorded and converted into tons per hectare. Cost of production of each irrigation and fertility levels were calculated by taking into account the current market price of each input (seeds, fertilizers, pesticides, *etc.*), cost of hired labour, machinery and irrigation during their respective cowpea-growing seasons (2013-14, 2014-15 and 2015-16). Gross returns of each irrigation and fertility levels were calculated from sale price of cowpea pod during their respective growing seasons. Net returns were calculated with gross returns subtracted by cost of production, whereas net benefit: cost (net B:C) ratio was calculated using formula, net returns divided by cost of production. Data were statistically analyzed using the analysis of variance (ANOVA) technique as applicable to split-plot design (Gomez and Gomez 1984). Least significant differences (LSD) were employed to assess differences between the treatment means at the 5% probability level.

Results and Discussion

Yield attributes and green pod yield

The pooled mean of yield attributes of cowpea viz; number of pods/plant, pod weight/plant and length of pod were significantly influenced due to different levels of irrigation and fertility (Table 1). Among the different irrigation levels cowpea irrigated at 1.2 IW/CPE ratio recorded significantly higher no. of pods/plant (~51), pod weight (206.9 gm) and length of pod

Table 1. Yield attributes and green pod yield of cowpea as influenced by various irrigation and fertility levels. (Pooled mean of 3 years).

Treatment	Pods/ plant (Nos.)	Pod weight/ plant (gm)	Pod length (cm)	Green pod yield (t/ha)
IW/CPE ratio (I)				
IW/CPE 0.8	45.2	181.9	13.9	8.22
IW/CPE 1.0	49.6	204.3	14.2	10.41
IW/CPE 1.2	51.4	206.9	14.2	10.79
SEm±	0.8	3.4	0.1	0.20
CD (P=0.05)	2.4	10.0	0.3	0.58
Fertility level (F)				
100% RDF	44.9	185.6	13.7	9.06
100% RDF + *Rhizobium* + PSB	52.0	205.9	14.4	10.34
75% RDF + *Rhizobium* + PSB	49.3	201.7	14.0	10.02
SEm±	0.8	3.1	0.1	0.14
CD (P=0.05)	2.2	8.9	0.2	0.40
Interactions				
I x F	NS	NS	NS	NS

RDF (Recommended dose of fertilizers), PSB (Phosphorus solubilizing bacteria)

(14.2 cm) over crop irrigated at 0.8 IW/CPE ratio. Cowpea irrigated at 1.0 IW/CPE ratio recorded similar no. of pods/plant (~50), pod weight (204.3 gm) and length of pod (14.2 cm) with crop irrigated at 1.2 IW/CPE ratio and significantly superior over irrigation at 0.8 IW/CPE ratio. A 14.0%, 13.7% and 3.0% increase in pods/plant, pod weight/plant and pod length were recorded when cowpea was irrigated at 1.2 IW/CPE ratio over IW/CPE ratio of 0.8. The correspond increase in pods/plant, pod weight/plant and pod length at 1.0 IW/CPE ratio were 10.0%, 12.3% and 3.0% over IW/CPE ratio of 0.8. Cowpea crop responded well to irrigation water as the crop sown in the summer season and under Gujarat conditions the temperature during the crop season was also high. Okon (2013) reported that water stress reduced growth performance of cowpea varieties especially on plant height and leaf area and ultimately pod yield. Mwai (2002) reported that cell growth and development is consisting of three stages; cell division, enlargement and differentiation. Morphologically, seedling height is perceived as an increase in plant size as indicated by parameters such as seedling height, moisture content and root length. Therefore reduced growth rate under water stress can be qualitatively related to reduced cell turgor or a reduction in the extensibility of the cell wall. Likewise, irrigation levels, all yield attributes of cowpea namely, no. of pods/plant, pod weight/plant and length of pod were also influenced due to the different fertility levels. Among various fertility levels, application of 100% RDF (recommended dose of fertilizers) + *Rhizobium* + PSB (phosphorus solubilizing bacteria) produced significantly higher no. of pods/plant (52.0), pod weight/plant (205.9 gm) and length of pod (14.4cm) over application of 100% RDF alone and application of 75% RDF + *Rhizobium* + PSB. The increase in percentage of pods/plant, pod weight/plant and length of pod due to application of 100% RDF + *Rhizobium* + PSB were 16%, 11% and 5% respectively, over 100% RDF. The improvement in yield attributing characters of cowpea with the application of 100% RDF + Rhizobium + PSB over 100% RDF is due to the balanced nutrition provided through the inclusion various bio-fertilizers, which had resulted in the better growth and finally green pod yield. In former treatment the availability of nitrogen as well as phosphorus was increased through the atmospheric nitrogen fixation by *Rhizobium* bacteria and phosphorus solubilisation by PSB, respectively. Chatterjee, and Bandyopadhyay (2017) conducted experiment to assess the effect of boron, molybdenum and biofertilizers on growth, nodulation and pod yield of vegetable cowpea and reported the combined use of seed treatment with molybdenum (0.5 g/kg seed) and biofertilizers (*Rhizobium* and PSB) along with foliar spray of boron significantly enhanced the growth and yield attributes of cowpea and registered 42% and 54% improvement in number of pod and pod yield/plant, respectively, over control.

The data presented in Table 1 indicated that green pod yield of cowpea was significantly influenced due to the application of different irrigation and fertility levels. Application of irrigation water at 1.2 IW/CPE ratio produced significantly higher pod yield (10.79 t/ha) over application of irrigation water at 0.8 IW/CPE ratio (8.22 t/ha) and it was remain at par with irrigating the cowpea at 1.0 IW/CPE ratio (10.41 t/ha). The increase in green pod yield of cowpea due the application of irrigation water at 1.2 IW/CPE ratio was 31% and 4% higher compared to crop irrigated at 0.8 IW/CPE ratio and 1.0 IW/CPE ratio, respectively. This increment was because of better growth of the crop with proper availability of moisture at 1.2 IW/CPE as compared to other treatments. Green pod yield of cowpea was also influenced due to the different fertility levels (Table 1). Significantly higher pod yield of 10.34 t/ha was observed with the application of 100% RDF + *Rhizobium* + PSB compared to 100% RDF alone (9.06 t/ha) and remain at par with 75% RDF + *Rhizobium* + PSB (10.02 t/ha). The pod yield increased with the application of 100% RDF + *Rhizobium* + PSB was 14% and 3% higher as compared to 100% RDF and 75% RDF + *Rhizobium* + PSB, respectively. Interaction effect between irrigation and fertility levels was found non-significant. *Rhizobium* and PSB containing biofertilizers might have improved the available nitrogen and phosphorus status of the soil by means of biological nitrogen fixation and phosphorus solubilization (Chatterjee, and Bandyopadhyay, 2017; Meena *et al.*, 2015). Asokan *et al.* (2000) reported that seed inoculation with biofertilizers supplied the bioactive compounds such as vitamins, hormones, and enzymes which influenced the plant metabolism. The availability and optimum supply of essential nutrients such as nitrogen and phosphorus influenced the plant vigor, morphology and metabolic processes, which ultimately enhanced the pods per plant and total pod yield of cowpea.

Economics

Cost of production, gross return, net returns and net benefit: cost ratio (net B:C ratio) of cowpea were significantly influenced due to the different irrigation and fertility levels (Table 2). Among different irrigation levels, the highest gross returns (Rs. 215880/ha) and net returns (Rs. 154917/ha) was recorded with the application of irrigation at 1.2 IW/CPE ratio as compared to

Table 2. Cost of production, gross return and net benefit: cost ratio of cowpea as influenced by various irrigation and fertility levels. (Pooled mean of 3 years).

Treatment	Cost of production (Rs./ha)	Gross return (Rs./ha)	Net profit (Rs./ha)	Net benefit: cost ratio
IW/CPE ratio (I)				
IW/CPE 0.8	50137	164300	114163	2.28
IW/CPE 1.0	55623	208260	152637	2.74
IW/CPE 1.2	60963	215880	154917	2.54
SEm±	-	-	3266	0.05
CD (P=0.05)	-	-	11302	0.16
Fertility level (F)				
100% RDF	55493	181260	125767	2.27
100% RDF + Rhizobium + PSB	55866	206800	150934	2.70
75% RDF + Rhizobium + PSB	55364	200380	145016	2.62
SEm±	-	-	2741	0.05
CD (P=0.05)	-	-	8144	0.13

RDF (Recommended dose of fertilizers), PSB (Phosphorus solubilizing bacteria) cowpea irrigated at 0.8 IW/CPE (Rs. 164300/ha and Rs.114163/ha) and 1.0 IW/CPE (Rs. 208260/ha and Rs.154917/ha) whereas, significantly higher net B:C ratio (2.74) was recorded when cowpea irrigated at 1.0 IW/CPE over 1.2 IW/CPE (2.54) and 0.8 IW/CPE (2.28). The higher gross returns and net returns at 1.2 IW/CPE was due to the higher pod yield in this treatment and higher net B:C ratio at 1.0 IW/CPE was due to the less cost involved in irrigating the crop as well as similar green pod yield obtained with this treatment over irrigating the crop at 1.2 IW/CPE treatment. As for as fertility levels are concerned, application of 100% RDF + *Rhizobium* + PSB realized significantly higher gross returns (Rs. 206800/ha), net returns (Rs. 150934/ha) and net B:C ratio (2.70) compared to 100% RDF and remain at par the application of 75% RDF + *Rhizobium* + PSB. The higher economic benefit in cowpea due to the application of 100% RDF + *Rhizobium* + PSB and 75% RDF + *Rhizobium* + PSB compared to 100% RDF alone was due to the inclusion of bio-fertilizers (*Rhizobium* and PSB) in former treatments which leads to higher pod yield and ultimately higher economic returns.

On the basis of the experimental results it may be concluded that irrigation and fertilizer treatments significantly affect the growth, green pod yield and economics of summer cowpea. The application of irrigation water in summer cowpea either at 1.0 or 1.2 IW/CPE ratios may be followed for realizing the optimum pod yield and economic returns. In case of crop nutrition, inclusion of *Rhizobium* + PSB with 100% RDF or 75% RDF may be recommended for summer cowpea for higher growth, green pod yield and economic returns under North Gujarat conditions.

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