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Interactive Effect of Irrigation at Critical Growth Stages and Phosphorus on Growth, Yield and Root Nodulation of Summer Blackgram

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The field experiment was conducted at College Agronomy Farm, Anand Agricultural University, Anand, Gujarat. Treatment combinations comprised of three levels of irrigation scheduling based on critical growth stages *viz*., I_1 (irrigation at branching and at flowering), I_2 (irrigation at branching, at flowering and at pod formation) and I_3 (irrigation at branching, at flowering, at pod formation and at grain filling stage) in main plot and three levels of phosphorus *viz*., P_0 (0 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}) and P_2 (40 kg P_2O_5 ha^{-1}) in sub plot were tested in split plot design with four replications using blackgram cv. Gujarat Urd 1. Growth and yield attributes of black gram were significantly affected due to irrigation scheduling based on critical growth stages . Significantly highest seed and straw yield of black gram were obtained under I_3 (irrigation at branching, at flowering, at pod formation and at grain filling stage) as compared to other. Phosphorus application @ 40 kg P_2O_5 ha^{-1} (P_2) produced significantly the highest seed yield (1246 kg ha^{-1}) and straw yield (3271 kg ha^{-1}), which were increased to extent of 38.44 and 30.21 % respectively over treatment P_0 (0 kg P_2O_5 ha^{-1}). The higher net realization of (Rs. 34922 ha^{-1}) with BCR value of 3.08 was recorded with treatment I_3 and in treatment P_2 40 kg P_2O_5 ha^{-1}) (Rs. 35686 ha^{-1}) with BCR 3.26.

Key words: Critical growth stages, Black gram, Phosphorus and BCR.

Among the pulses, blackgram (*Phaseolus mungo* L. Hepper) is one of the important pulse crops grown in India which belongs to the family '*Fabaceae*'. It plays an important role in maintaining and improving the soil fertility by atmospheric nitrogen fixation through root nodules. It fixes about 40 kg ha^{-1} atmospheric nitrogen, which is sub-sequently beneficial to the succeeding crop (Bhatt *et al*., 2012). Quantitatively black gram is very good source of protein (25-26 %) besides this, it contains 56.6 % carbohydrates, 1.2 % fats, 3.5 % minerals, 0.43 % lysine, 0.10 % methionine, 0.04 % tryptophan, 185 mg calcium, 345 mg phosphorus and 8.7 mg iron. Both excess and deficit use of water reduces the crop yield. Excess water leads to the problems of raising water table, soil salinity or alkalinity. Certain physiologically growth stages are critical at which there should not be any moisture stress. Phosphorus helps in proper root development which increases root nodules and consequently increases nitrogen fixation.

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MATERIALS AND METHODS

A field experiment was conducted during summer season of the year 2013 to study "Interactive effect of irrigation at critical growth stages and phosphorus on growth, yield and root nodulation of summer blackgram under middle Gujarat conditions. The soil is representative of the soil of the region, alluvial in origin, popularly known as "*Goradu*" soil. The texture of the soil is sandy loam and belongs to the order Inceptisols. The soil of the experimental plot was sandy loam in texture having good drainage, low in available nitrogen, medium in available phosphorus and high in available pottash with 7.6 soil pH. The soil was sandy loam in texture, soil depth 0-15 cm content (Organic carbon 0.38 %, available nitrogen 110.28 kg ha^{-1}, available phosphorus 42.74 kg ha^{-1}, and available potassium 344.30 kg ha^{-1}. Gujarat Urd 1 was sown during summer season of year 2013 at first week of March with seed rate 20 kg ha^{-1} in row to row spaced at 45 cm and fertilized with 20 kg N ha^{-1} as basal dose. The experiment was laid out in split plot design with four replications. Consisting of three levels of irrigation scheduling based on critical growth stages *viz.*, I_1 (irrigation at branching and at flowering), I_2 (irrigation at branching, at flowering and at pod formation) and I_3 (irrigation at branching, at flowering, at pod formation and at grain filling stage) in main plot and three levels of phosphorus *viz*., P_0 (0 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}) and P_2 (40 kg P_2O_5 ha^{-1}) in sub plot were evaluated in present study. The value of table F at 5 % level significance, where the treatment difference between were found significant the value of CD and CV % were also worked out to compare the treatment mean (Snedecor and Cochran, 1967).

RESULT AND DISCUSSION

Yield attributes and yield

Significantly the highest number of branches $plant^{-1}$ was observed under treatment I_3 (irrigation at branching, at flowering, at pod formation and at grain filling). Irrigation scheduling treatments did not show their significant influence on dry weight of root nodules $plant^{-1}$ of black gram at 45 DAS while days to maturity was found significant. Minimum days to maturity was observed under treatment I_1 (irrigation at branching and at flowering). Higher pods in irrigation scheduling I_3 could be due to the occurrence of sufficient available soil moisture condition in the root zone during crop growth period and have a better nutrient availability thereby increasing number of pods $plant^{-1}$. The results are in accordance with those reported by Verma *et al.* (2008) and Thomas *et al*. (2010). Irrigation scheduling I_3 (irrigation at branching, at flowering, at pod formation and at grain filling) produced significantly the highest seed and straw yield of blackgram (Table 1).

Treatment P_2 application of 40 kg P_2O_5 ha^{-1} registered significantly higher dry weight of root nodules $plant^{-1}$ (35.24 mg). The increase in dry weight of root nodules $plant^{-1}$ under P_2 over P_0 It might be due to positive effect of higher level of phosphorus on root growth promoted activity on *rhizobia* on plant roots and induced nodulation. Similar results are also observed by Meena *et al*. (2002) and Singh *et al*. (2012). Treatments P_2 (40 kg P_2O_5 ha^{-1}) produced significantly the highest (38.84) number of pods $plant^{-1}$ which was with higher to the tune of 20.62 and 12.22 % over treatments P_0 (0 kg P_2O_5 ha^{-1}) and P_1 (20 kg P_2O_5 ha^{-1}), respectively. The favourable effect of phosphorus application on number of pods $plant^{-1}$ was mainly due to its significantly favourable effects noted in plant height and number of branch $plant^{-1}$. This finding is analogous to those reported by Jadav *et al*. (2011) and Chesti *et al*. (2012). Successive increase in phosphorus levels from 0 to 40 kg ha^{-1} achieved significant increase in seed and straw yield of black gram. Phosphorus application @ 40 kg P_2O_5 ha^{-1} (P_2) gave significantly the highest seed and straw yield. It might be due to phosphorus is known to play beneficial role in legume growth by promoting extensive root development and nodulation and thereby ensuring proper growth and seed yield. This was in accordance with the result of Kumawat *et al*. (2013) and Singh *et al*. (2013).

FWUE and Economics

Higher (4.70 kg ha-mm^{-1}) field water use efficiency (Table 2) was observed under irrigation treatment I_1 (irrigation at branching and at flowering). Higher field water use efficiency was mainly because of less reduction in seed yield and greater reduction to total water supply. These findings are analogous to those reported by Patel *et al*. (2005) and Singh *et al*. (2006). Irrigation scheduling did not show significant influence on protein content of black gram. The maximum net realization of (Rs. 34922 ha^{-1}), respectively with BCR value of 3.08 was recorded with treatment I_3

(irrigation at branching, at flowering, at pod formation and at grain filling). The similar results were reported by Mandal *et al*. (2005).

Significantly the highest field water use efficiency (5.14 kg ha-mm^{-1}) was observed under treatment P_2 (40 kg P_2O_5 ha^{-1}), followed by P_1 (20 kg P_2O_5 ha^{-1}) with 4.19 kg ha-mm^{-1} (Table 2). The increase in field water use efficiency with phosphorus application might be due to favourable effect of phosphorus on better vegetative growth, pod and seed formation with increased the seed yield without much increasing the water uptake. The similar findings were also reported by Mandal *et al*. (2005). Maximum net realization (Rs. 35686 ha^{-1}), respectively were accrued with treatment P_2 (40 kg P_2O_5 ha^{-1}) with BCR 3.26. The results confirm the findings of Singh *et al*. (2012) and Kumawat *et al*. (2013).

Interaction

Significantly higher number of seeds pod^{-1} (Table 1a) was observed in treatment combination I_3P_2 (irrigation at branching, at flowering, at pod formation and at grain filling with 40 kg P_2O_5 ha^{-1}). Seed yield was significantly higher (Table 1b) in treatment combination I_3P_2 (irrigation at branching, at flowering, at pod formation and at grain filling with 40 kg P_2O_5 ha^{-1}) but it was at par with treatment combinations I_2P_2 (irrigation at branching, at

Table 1. Influenced of irrigation scheduling and phosphorus levels on yield attributes and yield of summer blackgram

Treatments	Dry wt. of root nodules plant^{-1} at 45 DAS (mg)	No. branches plant^{-1}	Days to maturity	No. pods plant^{-1}	No. of seeds pod^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Irrigation scheduling (at critical growth stages) (I)							
I_1: Branching + Flowering	33.15	5.69	69.42	31.70	4.15	890	2223
I_2: Branching + Flowering + Pod formation	33.89	6.53	71.96	35.58	4.80	1034	2893
I_3: Branching + Flowering + Pod formation + Grain filling	35.08	7.13	76.31	37.87	5.31	1250	3434
S.Em.±	0.74	0.17	1.03	0.78	0.07	29	79
C.D. (P=0.05)	NS	0.59	3.58	2.71	0.25	101	272
Levels of Phosphorus (kg P_2O_5 ha^{-1}) (P)							
P_0: 0	32.83	5.65	71.72	32.20	4.60	900	2512
P_1: 20	34.05	6.69	72.60	34.61	4.74	1028	2768
P_2: 40	35.24	7.04	73.37	38.84	4.92	1246	3271
S.Em.±	0.46	0.16	0.79	0.49	0.05	20	51
C.D. (P=0.05)	1.31	0.47	NS	1.40	0.15	57	146
Interaction(I × P)	NS	NS	NS	NS	Sig.	Sig.	NS

Table 1(a). Interaction effect of irrigation scheduling and phosphorus levels on number of seeds pod^{-1} of summer black gram

Irrigation scheduling (I)	Phosphorus (P) No. of seeds pod^{-1}		
	P_0	P_1	P_2
I_1	4.13	4.14	4.18
I_2	4.49	4.78	5.15
I_3	5.20	5.30	5.43
S.Em.±	0.09		
C.D. (P=0.05)		0.26	

Table 1(b). Combine effect of irrigation scheduling at critical growth stages and phosphorus levels as influenced by seed yield on summer black gram

Irrigation scheduling (I)	Phosphorus (P) No. of seeds pod^{-1}		
	P_0	P_1	P_2
I_1	728	795	1149
I_2	839	1046	1266
I_3	1182	1243	1322
S.Em.±		34	
C.D. (P=0.05)		98	

Table 2. Influenced of irrigation scheduling and phosphorus levels on FWUE, protein content and economics of summer black gram

Treatments	FWUE (kg ha-mm^{-1})	Protein content (%)	Net realization (Rs. ha^{-1})	BCR
Irrigation scheduling (at critical growth stages) (I)				
I_1: Branching + Flowering	4.70	21.50	20917	2.32
I_2: Branching + Flowering + Pod formation	4.34	22.22	26512	2.63
I_3: Branching + Flowering + Pod formation + Grain filling	4.17	22.57	34922	3.08
S.Em.±	0.12	0.42	-	-
C.D. (P=0.05)	0.42	NS	-	-
Levels of Phosphorus (kg P_2O_5 ha^{-1}) (P)				
P_0: 0	3.88	20.79	23461	2.70
P_1: 20	4.19	22.14	27711	2.87
P_2: 40	5.14	23.36	35686	3.26
S.Em.±	0.09	0.24	23461	2.70
C.D. (P=0.05)	0.27	0.68	-	-
Interaction(I × P)	Sig.	NS	-	-

Table 2(b). Combine effect of irrigation scheduling at critical growth stages and phosphorus levels as influenced by FWUE on summer black gram

Irrigation scheduling (I)	Phosphorus (P) No. of seeds pod^{-1}		
	P_0	P_1	P_2
I_1	4.06	4.18	5.87
I_2	3.94	4.07	5.01
I_3	3.63	4.03	4.21
S.Em.±		0.13	
C.D. (P=0.05)		0.38	

flowering and at pod formation with 40 kg P_2O_5 ha^{-1}) and I_3P_1 (irrigation at branching, at flowering, at pod formation and at grain filling with 20 kg P_2O_5 ha^{-1}). Treatment combination I_1P_2 noted significantly the highest field water use efficiency than the rest of treatment combinations (Table 2a).

CONCLUSION

From the result of experiment, it is concluded that for securing higher seed yield and profit from black gram during summer season crop should be irrigated at branching, flowering, pod formation and grain filling and fertilized along with 40 kg P_2O_5 ha^{-1} on sandy loam soil of Middle Gujarat.

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