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Growth, yield, and water use efficiency of green gram (*Vigna radiata* L.) as influenced by irrigation scheduling and land configuration

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ABSTRACT

A field experiment was conducted at experimental area, School of Agriculture, Lovely Professional University during the *kharif* season of 2022 to evaluate the growth and productivity of green gram (*Vigna radiata* L.) as influenced by irrigation scheduling and land configuration. The experiment was laid out in split plot design replicated four times with 2 main plots (L_1: flat-bed and L_2: raised bed) and 4 sub-plots (I_1: irrigation at pre-flowering stage; I_2: irrigation at seedling + pre-flowering stage; I_3: irrigation at pre-flowering stage + pod formation stage; I_4: irrigation at seedling stage + irrigation at pre-flowering stage+ irrigation at pod formation stage). The results indicated that when given three irrigations under raised bed had significantly better effect on growth and yield of green gram (*Vigna radiata* L.). The maximum plant height (67.23cm), number of branches (14.53), dry matter accumulation (17.75g) at harvest, pods/plant (46.58), seed yield (15.25q ha^{-1}), stover yield (29.55q ha^{-1}) and water use efficiency (7.63kg/ha-mm) were recorded higher under treatment combination of L_2I_4 (raised bed + irrigation at seedling, irrigation at pre-flowering and irrigation at pod formation stage) than rest of other treatments.

Key words: *Land configuration, Irrigation scheduling, Water use efficiency, Growth, yield.*

Introduction

India is the world's greatest producer and consumer of pulses, accounting for 33% of the global area and 22% of the global pulse production (Reager *et al.*, 2020). Pulses are the cheapest and most concentrated form of dietary amino acids in a vegetarian culture like India, where protein demand is mostly met by pulses. India is the world's top producer of pulses (25% of global output), consumer (27% of global consumption) and importer (14%) (Patel *et al.*, 2020). Green gram [*Vigna radiata* (L), one of the important pulses in India, has 4.5 million hectares area under cultivation, with a total production of 2.5 million tonnes and productivity of 548 kg/ha, contributing 10% to the total production (Anon., 2021). Green gram has significant amount of protein and is easier to digest than other pulses. Though pulse crops are nutritionally richer than cereals, they have comparatively lower productivity. In order to increase productivity, various crop management practices need to be optimized. Irrigation management is one such practice especially under increasing water scarcity. The main goal is to maximise yield by using water in the most efficient manner possible. It is preferable to apply irrigation at a rate that is not greater than the crop's demand, nor to save water to the point where agricultural plants are

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subjected to severe water stress, which has a negative impact on production. Among various scientific approaches for scheduling irrigation, maintaining moisture at critical growth stages of crop can be an easier option for the farmers, especially for short duration pulses. Along with optimum irrigation, suitable land configuration also helps in maximizing rainfall infiltration and minimizing runoff losses which ultimately improves water use efficiency. Sowing green gram on flat beds is more popular but it results in surface compaction and excessive moisture sometimes, which might impact plant development. Land layout, by adjusting the soil physical environment, can play an important role in increasing population through unrestricted and uniform germination (Rath and Gulati, 2020). While flooding the field, changing the land configuration to raised bed planting can be more promising technique to assure regulated irrigation (Joshi *et al*., 2020). Raised bed method of sowing not only saves irrigation water but also saves the crop from adverse effect of heavy rainfall and increases yield over flat -bed sowing. Keeping above points into consideration, present investigation was designed to evaluate the combined effect of irrigation levels and land configuration on productivity of green gram.

Materials and Methods

A field experiment was carried out during *Kharif* season of 2022 at Agriculture farm, School of Agriculture, Lovely Professional University, Phagwara. The region falls under Trans-Gangetic plains of India and experimental site had sandy loam soil. The test crop was green gram *cv.* ML-1808. The soil physio-chemical values furnished in Table 1. The experiment was laid out in split plot design with 2 main plot treatments *viz.* flat-bed (L_1) and raised bed (L_2) and 4 sub-plot treatments *viz.* irrigation at pre-flowering stage (I_1), irrigation at seedling + pre-flowering stage (I_2), irrigation at pre-flowering stage + pod formation stage (I_3), irrigation at seedling stage + irrigation at pre-flowering stage + irrigation at pod formation stage (I_4). The 8 treatment combinations were replicated 4 times. Crop was sown at a spacing of 30×10 cm with seed rate of 20kg ha^{-1}. Entire amount of nitrogen, phosphorus and potassium were applied as basal at a dose of 25:40:20 kg ha^{-1}. The crops was sown on 12th July 2022 and harvested on 21st September. One hand weeding was done to minimize early crop-weed competition. From each plot, five plants were tagged to record growth and yield attributing characters. The seed yield was recorded and expressed in q ha^{-1}.

Statistical analysis

Experimental data were processed, placed into an inventory sheet in MS excel and then put through statistical analyse that use web-based OPSTAT software in the split-pot (SPD) experimental design. The ANOVA was built to perform further inference. The appropriate LSD at the 0.05 level of probability were obtained for each case in order to the comparison of the treatment mean.

Results and Discussion

Growth parameters

Data pertaining to various growth parameters of green gram as influenced by the effect of irrigation scheduling and land configuration is furnished in Table 2. Different land configurations as well as irrigation levels significantly affected plant height, number of branches and dry matter accumulation at 30, 60 DAS, and at harvest. However, the interaction between land configuration and irrigation scheduling was found to be non-significant. Significantly higher plant height (39.67, 62.49, 64.13 cm), number

Table 1. Initial soil physio- chemical values of the experimental soil.

S.No.	Properties	values	Method
1.	Soil texture	Sandy loam	International pipette method (Piper, 1966)
2.	Chemical properties		
	pH	7.10	Potentiometry (Jackson, 1973)
	EC (dS m^{-1})	0.18	
	Organic carbon (%)	0.39	Walkley and Black method (Jackson, 1973)
	Available N (kg/ha)	125	Alkali permanganate method (Subbiah, 1956)
	Available P (kg/ha)	22.17	Olsen's method (Olsen, 1954)
	Available K (kg/ha)	126.67	Flame photometry (Jackson, 1973)

Table 2. Effect of irrigation scheduling and land configuration on Plant on growth parameters of green gram

Treatments	Plant height (cm)			Number of branches			Dry matter accumulation (g/m²)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Land configuration (L)									
L_1	36.67	59.99	61.48	6.01	12.57	12.77	2.81	14.64	15.67
L_2	39.67	62.49	64.13	6.41	13.50	13.58	3.29	15.68	16.45
SEm±	0.11	0.38	0.13	0.08	0.05	0.05	0.04	0.09	0.04
LSD (P=0.05)	0.52	1.70	0.60	0.36	0.23	0.23	0.18	0.40	0.19
Irrigation scheduling (I)									
I_1	35.67	56.26	57.90	5.56	11.09	11.29	2.23	12.85	13.21
I_2	39.99	58.76	60.26	6.63	12.73	12.95	3.45	14.24	16.13
I_3	36.88	64.25	65.83	5.73	13.90	13.94	2.64	16.50	17.15
I_4	40.15	65.68	67.23	6.93	14.43	14.53	3.88	17.05	17.75
SEm±	0.33	0.49	0.53	0.21	0.19	0.20	0.10	0.20	0.11
LSD (P=0.05)	0.97	1.45	1.59	0.61	0.56	0.60	0.28	0.60	0.33

L_1: flatbed, L_2: raised bed, I_1: irrigation at pre-flowering stage, I_2: irrigation at seedling and pre-flowering stages, I_3: irrigation at pre-flowering stage and pod formation stages, I_4: irrigation at seedling, pre-flowering and pod formation stages.

of branches (6.41, 13.50, 13.58) and dry matter accumulation (3.29, 15.68, 16.45 g/m^2) at 30, 60 DAS and at harvest were recorded under raised bed method of sowing over flat-bed sowing. This may be because under raised beds, a proper balance is maintained between soil moisture and air. This facilitates better root respiration, allowing crop to establish strong root systems and access essential nutrients and sufficient moisture easily. Well-developed root systems and better nutrient absorption results into more vigorous plant growth.

Among various irrigation scheduling treatments, irrigation scheduled at seedling, pre-flowering and pod formation stages resulted in significantly higher plant height (40.15, 65.68, 67.23cm), number of branches at (6.93, 14.43, 14.53) and dry matter accumulation (3.88, 17.05, 17.75g/m^2) at 30, 60 DAS and at harvest. However, irrigation applied at seedling and pre-flowering stages also produced at par results with plant height of 39.99, 36.88 and 40.15 cm, number of branches as 6.63, 12.73 and 12.95 and dry matter accumulation of 3.45, 14.24, 16.13 g/m^2. Better growth of crop under these treatments might be due to sufficient availability of moisture at the critical growth stages which ensured proper cell division and expansion and thereby stem elongation. This led to overall increase in various growth parameters.

Yield attributes and yield

Data on various yield attributes and yield of green gram as influenced by different treatments as presented in Table 3a revealed that different land configurations as well as irrigation levels significantly affected yield attributes *viz.* pods/plant, length of pod, seeds/pod, seed index and both seed and stover yield, except test weight of the seeds which remained unaffected. There was significant interaction between land configuration and irrigation scheduling as observed for the yield attributes and yield (Table 3b). Significantly higher number of pods/plant (40.26), length of pod (9.06 cm), number of seeds/pod (11.38), seed yield (12.32qha^{-1}), stover yield (23.74 qha^{-1}), and harvest index (34.11%) were recorded under raised bed method of sowing over flat-bed sowing. This may be a result of loose soil composition of raised beds which ensured better air circulation around the plant roots. This promotes optimal oxygen levels in the soil, which is crucial for root respiration and nutrient uptake, ensuring that plants receive the necessary nutrients for healthy growth, which lead to better formation and assimilation of dry matter in the yield attributing traits. Yield being a function of various yield attributes, was also improved.

Among various irrigation scheduling treatments, irrigation scheduled at seedling, pre-flowering and pod formation stages resulted in significantly higher pods/plant (44.01), length of pod length (9.70cm), seeds/pod (12.00), seed yield (14.37qha^{-1}) and stover yield (28.29qha^{-1}). However, irrigation applied at pre-flowering and pod formation stages also produced at par results with pods/plant (42.98), length of pod (9.30 cm), seeds/pod (11.70), seed yield (13.81 q ha^{-1}) and stover yield (26.99 q ha^{-1}). Irrigation during the pre-flowering and pod formation stages is critical for the growth and developments of pods. Sufficient moisture availability ensures that the developing pods remain plump and well-filled. Proper water supply facilitates better nutrient uptake, metabolic process, cell expansion and partitioning of dry matter from vegetative to reproductive parts, thus resulting in proper seed formation.

Among different treatment combinations evaluated, raised bed with irrigation scheduled at seedling, pre-flowering and pod formation stages resulted in significantly higher pods/plant (46.58), length of pod (9.95 cm), seeds/pod (12.43), seed yield (15.25 q ha^{-1}) and stover yield (29.55 q ha^{-1}). Performance of crop on raised with irrigation scheduled at pre-flowering and pod formation stages was also found to be equally good as it produced higher pods/plant (45.78), length of pod (9.80 cm), seeds/pod (12.10), seed yield (14.77 q ha^{-1}) and stover yield (27.82 q ha^{-1}).

Table 3a. Effect of irrigation scheduling and land configuration on yield attributes of green gram.

Treatments	Pods/ plant	Pod length (cm)	Seeds/ pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
Land configuration(L)							
L_1	35.23	8.20	10.19	42.38	10.21	20.77	32.94
L_2	40.26	9.06	11.38	43.31	12.32	23.74	34.11
SEm±	0.31	0.05	0.07	0.74	0.10	0.24	0.23
LSD(p=0.05)	1.40	0.17	0.32	NS	0.46	1.08	1.03
Irrigation scheduling (I)							
I_1	28.74	7.20	9.15	43.25	7.53	15.02	33.35
I_2	35.24	8.31	10.29	42.50	9.35	18.72	33.25
I_3	42.98	9.30	11.70	43.13	13.81	26.99	33.84
I_4	44.01	9.70	12.00	42.50	14.37	28.29	33.66
SEm±	0.43	0.05	0.09	1.30	0.20	0.44	0.36
LSD(p=0.05)	1.29	0.16	0.26	NS	0.58	1.31	NS

L_1: flatbed, L_2: raised bed, I_1: irrigation at pre-flowering stage, I_2: irrigation at seedling and pre-flowering stages, I_3: irrigation at pre-flowering stage and pod formation stages, I_4: irrigation at seedling, pre-flowering and pod formation stages.

Table 3b. Yield attributes and yield of green gram as influenced by interaction effect of irrigation scheduling and land configuration

Treatment	combinations pods/plant	Pod length (cm)	Seeds/ pod	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
L_1I_1	28.00	6.80	8.30	6.73	13.81	32.80
L_1I_2	31.28	7.75	9.58	7.78	16.07	32.68
L_1I_3	40.18	8.80	11.30	12.85	26.17	32.98
L_1I_4	41.55	9.45	11.58	13.49	27.04	33.30
L_2I_1	29.48	7.60	10.00	8.34	16.22	33.90
L_2I_2	39.20	8.88	11.00	10.92	21.37	33.83
L_2I_3	45.78	9.80	12.10	14.77	27.82	34.70
L_2I_4	46.58	9.95	12.43	15.25	29.55	34.03
SEm±	0.61	0.08	0.13	0.28	0.62	0.51
LSD(p=0.05)	1.82	0.22	0.37	0.83	1.85	NS

L_1I_1: flatbed+ irrigation at pre-flowering stage; L_1I_2: flatbed+ irrigation at seedlings and pre-flowering stages; L_1I_3: flatbed + irrigation at pre-flowering and pod formation stages; L_1I_4: flatbed + irrigation at seedling, pre-flowering and pod formation stages; L_2I_1: raised bed + irrigation at pre-flowering stage; L_2I_2: raised bed + irrigation at seedling and pre-flowering stages; L_2I_3: raised bed + irrigation at pre-flowering and pod formation stage; L_2I_4: raised bed + irrigation at seedling, pre-flowering and pod formation stages.

Field water use efficiency

Effect of irrigation scheduling and land configuration on field water use efficiency of green gram has been presented in Fig. 1. It was significantly influenced by both irrigation levels as well as land configuration and there was a significant interaction between both treatments. Significantly higher field water use efficiency was observed under raised bed when given two irrigations at pre-flowering and pod formation stages (9.84 kg/ha-mm). This increased water efficiency is a result of comparatively higher yield and lesser water applied under this treatment combination.

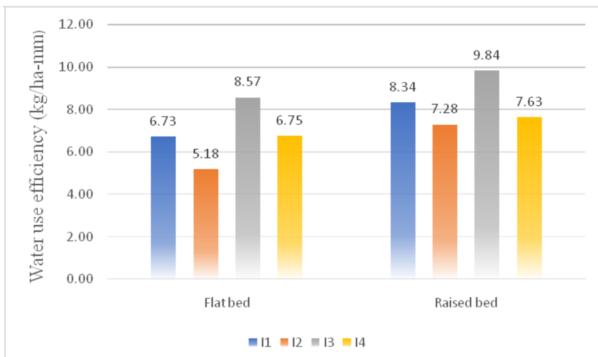

Fig. 1. Effect of irrigation scheduling and land configuration on water use efficiency of green gram

Conclusion

Based on the results obtained from this study, it can be concluded that green gram when grown on raised beds along with either three irrigations scheduled at seedling, pre-flowering and pod formation or two irrigations scheduled at pre-flowering and pod formation stages results in better growth and development of crops with enhanced productivity. Comparing both the irrigation scheduling treatments, as higher water use efficiency was observed under two irrigations at pre-flowering and pod formation stages due to lesser amount of water applied, it should be preferred for better water saving.

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