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RESEARCH ARTICLE

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Resource Use Efficiency and Economics of Summer Greengram as Influenced by Land Configuration and Irrigation Regimes in North-western Part of India

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ABSTRACT

Background: Pulses form a crucial protein component of the human diet and among the pulses, greengram is third most important pulse crop in India. Water is a critical input for sustained crop production and is becoming limited day by day. Hence, the need of the hour is to evaluate effective resource conservation practices, such as land configurations and scientific scheduling of irrigation to achieve higher productivity, profitability and resource use efficiency. The aim of the study was to identify most resource efficient and economical land configuration, irrigation regimes for summer greengram under sandy loam soils of northwestern India.

Methods: The experiment was conducted during the summer of 2022 on Student's farm, School of Agriculture, Lovely Professional University, Phagwara, Punjab to investigate the performance of summer greengram as influenced by land configuration and irrigation regimes. The experiment was carried out in a strip plot design consisting of 12 treatment combinations and three replications. The treatment included three land configurations *viz,* (L_1: Flatbed, L_2: Ridge and furrow and L_3: Broad bed furrow) and four different irrigation regimes [Irrigating at critical growth stages (I_1), 0.60 IW/CPE (I_2), 0.75 IW/CPE (I_3) and 0.90 IW/CPE (I_4)].

Result: Among three land configurations tried, L_3 recorded significantly higher water productivity, NUE and net return. Similarly, I_1 recorded significantly higher water productivity whereas I_4 recorded significantly higher NUE and net return. Among the treatment combinations, I_1L_3 recorded significantly higher water productivity (0.262 kg m^{-3}) whereas I_3L_3 recorded significantly higher NUE (25.16 kg seed kg nutrient^{-1}) and net income (₹ 72,848 ha^{-1}) as compared to other treatment combinations. Hence, I_1L_3 and I_4L_3 can be recommended to farmers for growing summer greengram under sandy loam soil conditions in water scare regions and assured irrigation situation, respectively.

Key words: Broad bed furrow, IW/CPE ratio, Nutrient use efficiency, Water productivity.

INTRODUCTION

Water is an essential component for agricultural activities, but its availability is becoming scares day by day. Out of 17 sustainable development goals of the global community, seven goals are related to the effective utilization and conservation of water resources. Thereby; signifying the role of water management and enhancing water productivity in achieving responsible consumption and production to build a poverty-free, hunger-free, sustainable and healthy society. Agriculture uses more than 80% of the world's freshwater resources, with a majority being allocated to crop production (Selvan *et al*., 2021). Developing countries heavily rely on rain-fed agriculture, which accounts for 60% of their food production (Marwein *et al*., 2017). Consequently, it is commonly observed that water scarcity during the crop growth and development leads to reduced crop yield. A sufficient water supply directly enhances crop growth and dry matter production while indirectly improving nutrient availability and utilization (Kaur and Singh, 2006). However, because of the increasing demand for water from various sectors and limited water supplies, there is an urgent need for improved irrigation management with precise irrigation scheduling. Therefore, there is a need for advancements in enhancing the water use efficiency of irrigation scheduling techniques (Kumar *et al*., 2019).

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Pulses form a crucial component of the vegetarian diet consumed by a significant portion of the population in India. Pulses play a vital role in the agricultural systems across worldwide by serving as an essential component of cropping practices in order to sustain crop productivity and soil health (Vani *et al*., 2021). Greengram is typically grown during the rainy season, early maturing varieties have proven to be suitable for spring and summer cultivationIndia plays a significant role in global pulse production as one of the major pulse-producing countries, contributing approximately 25% to the total output (Choudhary, 2009). Among the various pulse crops cultivated in India, greengram (*Vigna radiata* L.) holds the third position in terms of significance, occupying approximately 8% of the nation's total pulse cultivated area. World-wide, greengram is cultivated in 7.3 m ha with 5.3 m t production and 721 kg/ha productivity. In India, 3.17 m t is the production from 5.5 m ha area with average productivity of 570 kg/ha (Anonymous, 2023). Whereas, in Punjab it occupied 2.6 thousand hectares with total production of 2.5 thousand tonnes and average productivity of 960 quintals per hectare (Anonymous, 2022).

Effective resource conservation practices, such as land configurations and planting methods, play a crucial role in promoting the growth and development of crops. These practices significantly influence the effectiveness of various crop management techniques, including nutrient application, irrigation, weed management and planting geometry (Singh *et al*., 2016). The main objective of these practices is to conserve soil moisture in its original location (in situ), thereby enhancing water use efficiency, facilitating safe drainage of excess water from crop fields and minimizing water and nutrient losses (Halli and Angadi, 2019). Top of Form Numerous research studies have highlighted the significance of land configuration in creating an optimal environment for consistent germination, growth, flowering and pod development, leading to increased crop yield. The raised bed technique for sowing has been documented as beneficial in mitigating the impacts of temporary waterlogging and salt damage on plants. Further, the elevated section of the broad bed and furrow system improves aeration, reduces soil compaction and promotes optimal crop emergence (Akbar *et al*., 2007 and Bhadre *et al*., 2022). Hence, the selection of a suitable land configuration becomes crucial for the successful cultivation of greengram (Karikalan *et al*., 2020). Besides this, studies on interaction effect of land configuration and irrigation regimes on resource use efficiency and economics of summer greengram are very meager. By keeping all these above-mentioned points in view, this experiment was planned with an objective to identify the most efficient and economical land configuration and irrigation level for summer greengram under sandy loamy soils of Punjab.

MATERIALS AND METHODS

The experiment was conducted at Student's farm, School of Agriculture, Lovely Professional University, Punjab during summer season of 2022. The agriculture farm is situated at 31°14′34.7″N latitude and 75°41′46.0″E longitude. This falls under Trans-Gangetic Plain zone of Agro-Climatic Zone of Punjab at an altitude of 252 m above mean sea level. The type soil in the experiment site was sandy loam with slightly basic pH (7.25), normal EC (0.23 dS m^{-1}), low organic carbon (0.19%), low available nitrogen (203.0 kg ha^{-1}), moderate available phosphorus (15.1 kg ha^{-1}) and high available potassium (224.0 kg ha^{-1}). The cumulative rainfall received during crop growth period (13th April to 20th June, 2022) was 82.3 mm with three rainy days. Maximum temperature was ranged from 35 to 48°C with average evaporation of 5. 2 mm day^{-1}. The experiment was laid out on strip plot design with twelve different treatment combinations and three replications. The treatments included 3 land configurations *viz,* (L_1: Flatbed, L_2: Ridge and furrow and L_3: Broad bed furrow) which are taken as vertical factor (Plate 1) and 4 level of irrigation regimes namely (Irrigating at critical growth stages (I_1), 0.60 IW/CPE (I_2), 0.75 IW/CPE (I_3) and 0.90 IW/CPE (I_4) which are taken as horizontal factor in strip plot design. Healthy and bold seeds of greengram variety SML 668 were sown manually @ 15 kg ha^{-1} at a spacing of 40 cm × 7 cm (Plate 1).

The seed was treated with Rhizobium two hours before the sowing with the help of water. N, P_2O_5 and K_2O were applied @ 12.5:38:0 kg/ha. Initially, one common sowing irrigation was given for uniform germination and establishment of the crop. Rest of the irrigations were scheduled according to treatments. I_1 treatment received four irrigations of six cm depth, each at critical growth stages *viz*., early vegetative stage, flowering, pod formation and pod filling stage. I_2, I_3 and I_4 treatments were irrigated at cumulative pan evaporation of 100 mm, 80 mm and 66 mm, respectively (Table 1). For calculating cumulative pan evaporation, the daily pan evaporation data obtained from Class A open pan evaporimeter that has been installed in Agro-meteorology observatory, Lovely Professional University, Punjab.

Water productivity and irrigation water use efficiency were calculated by using below mentioned formula:

$$\text{Water productivity (kg m}^{-3}\text{)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Total water applied in field (m}^{3}\text{)}}$$

$$\text{Irrigation use efficiecny (kg mm)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Total irrigation used (mm)}}$$

Biometric observations were recorded from five tagged plants that were chosen randomly from the net plot. The collected data were compiled and then analyzed statistically using Fischer's method of analysis of variance. The critical difference values at a significance level of 0.05, as described by (Gomez and Gomez, 1984), were utilized. To further examine the mean values of the main plot, sub plot and their interactions, the Duncan Multiple Range Test (DMRT) was applied, considering the respective error mean sum of square in SPSS software.

RESULTS AND DISCUSSION

Growth and yield performance

Land configuration plays a significant role in providing favorable goring environment to crop. Thereby affect growth and yield of a crops. Results of present study revealed that, different land configuration had significant effect on growth and yield of greengram. The broad bed method recorded significantly the highest plant height (58.8 cm), number of pods per plant (40.9) and seed yield (1129 kg ha^{-1}) when compared to other land configurations (Fig 1). The seed yield increment with broad bed method was to an extent of 21.6 per cent over flatbed method and 12.4 per cent over ridge and furrow method. This superiority of broad bed furrow might be due to the enhanced availability of soil moisture and adequate root aeration which might have promoted the strong root architecture, absorption of water and nutrients. This resulted in higher cell division and elongation leading to maximum plant growth, yield parameters and seed yield (Ramesh *et al*., 2020 and Porpavai *et al*., 2022). Whereas, flatbed method recorded significantly the lowest plant height (55.8 cm), number of pods per plant (38.8) and seed yield (886 kg ha^{-1}) when compared to other land configurations.

Different irrigation regimes had a significant effect on growth and yield performance of greengram. Irrigation at 0.90 IW/CPE ratio recorded significantly highest plant height (60.2 cm), number of pods per plant (41.8) and seed yield (1140 kg ha^{-1}) as compared to other irrigation regimes. This was mainly attributed to application of a greater number of irrigations (8) leading to higher availability of soil moisture in the root zone promoting higher growth and yield. Whereas irrigation at critical growth stages recorded significantly the lowest values when compared with other irrigation regimes. The results are in conformity with Karande *et al.* (2019).

Similarly, interaction effect of land configuration and irrigation regimes showed a significant difference on greengram. Irrigation at 0.90 IW/CPE ratio under broad

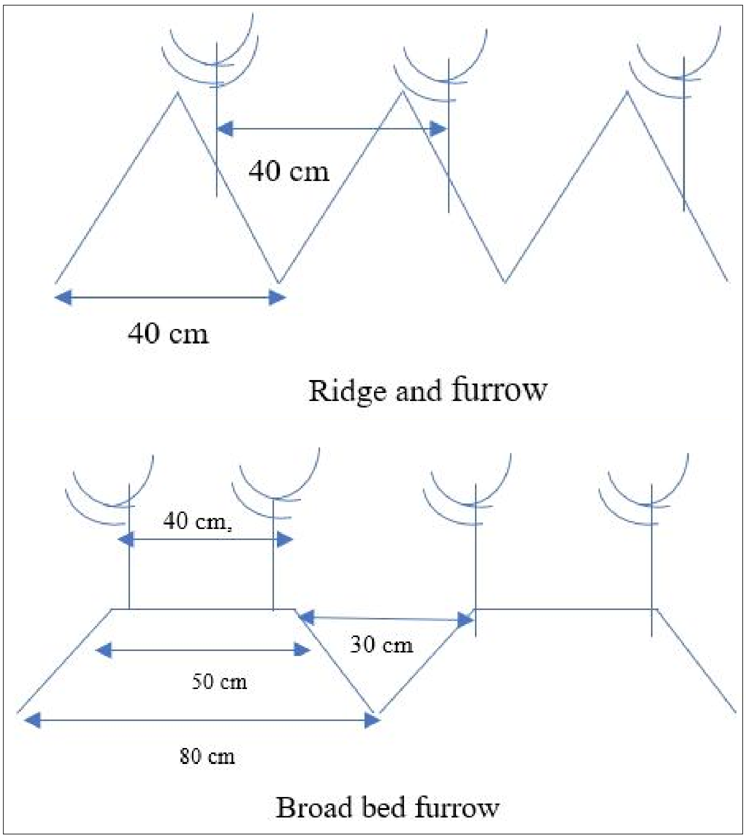

Plate 1: Schematic representation of land configurations.

Table 1: Total amount of water used by greengram under different irrigation regimes.

Treatment	No. of irrigation*	Effective rainfall (mm)	Irrigation applied (mm)	Total water applied (mm)
I_1	5	57.26	300	357.26
I_2	6	57.26	350	417.26
I_3	7	57.26	450	477.26
I_4	8	57.26	480	537.26

*Number of irrigation including sowing irrigation.

bed furrow recorded significantly the highest plant height (62.5 cm), number of pods per plant (43.8) and seed yield (1321.0 kg ha^{-1}). This may be due to the optimal soil moisture content attained in this irrigation practices contributing to the increased carbon synthesis and subsequent accumulation of photosynthates in the sink. These findings are similar with Idnani and Gautam (2008).

Total water used, irrigation water use efficiency and water productivity

Different land configurations had a significant effect on irrigation water use efficiency (IWUE) and water productivity (WP) of greengram. Significantly the highest IWUE (2.94 kg ha-mm^{-1}) and WP (0.257 kg m^{-3}) were recorded with broad bed method. This was mainly attributed to the fact that; reduced water loss, better water infiltration into the soil and enhanced water availability in broad bed furrow. This might have led to increased water availability for crop uptake and effectiveness of irrigation. Contrarily, the lowest irrigation water use efficiency (2.35 kg ha-mm^{-1}) and water productivity (0.202 kg m^{-3}) were recorded with flatbed method. These results are supported by the results of Ahlawat and Gangaiah (2010) and Sodavadiya *et al.* (2017). Among the irrigation regimes, significantly the highest IWUE (3.00 kg ha-mm^{-1}) and WP (0.244 kg m^{-3}) were recorded with irrigation at critical crop growth stages as compared to rest of the irrigation treatments. However, irrigation at 0.75 IW/CPE ratio found on par with water productivity. This might be due to the fact that, increased proportion of yield with applied water (Sodavadiya *et al.*, 2017 and Halli and Angadi, 2019). There was 37.5% and 33.5% higher irrigation water and total water usage under irrigation at 0.90 IW/CPE ratio over irrigation at critical growth stages. However, there was decrease in IWUE and WP with increased amount of irrigation water (Table 2). This might be due to the fact that, there was no proportionate increase in yield with increased irrigation water. Though I_4 received highest irrigation water, it produced the lowest WP. This might be due the fact that, ineffective usage applied irrigation water due to losses of applied water through deep percolation and evaporation in higher irrigation regimes. These findings were in line with the results reported by Singh *et al.* (2018), Gull *et al.* (2019) and Sujatha *et al.* (2023).

Interaction effect of land configuration and irrigation regimes showed a significant effect on IWUE and WP. Irrigating the crop at critical growth stages under broad bed furrow recorded significantly highest IWUE (3.24 kg ha-mm^{-1}) and WP (0.262 kg m^{-3}) when compared with other treatments. However, it was on par with irrigating the crop at 0.60, 0.75 and 0.90 IW/CPE ratio under broad bed furrow with respect to WP. This was mainly due to positive interaction of broad bed furrow and higher irrigation water application. Irrigating the crop at 0.90 IW/CPE ratio under flatbed method recorded significantly the lowest IWUE (2.09 kg ha-mm^{-1}) and WP (0.187 kg m^{-3}). This may be due to flat surface of the field which exposed higher soil surface to the sun, resulting in higher rates water loss through evaporation, deep percolation and runoff (Pramanik *et al.*, 2009 and Sodavadiya *et al.*, 2017).

Nutrient use efficiency

The nutrient use efficiency (NUE) of greengram differed significantly with different land configuration (Table 2). However, broad bed furrow method of land configuration recorded significantly highest NUE (21.5 kg seed kg

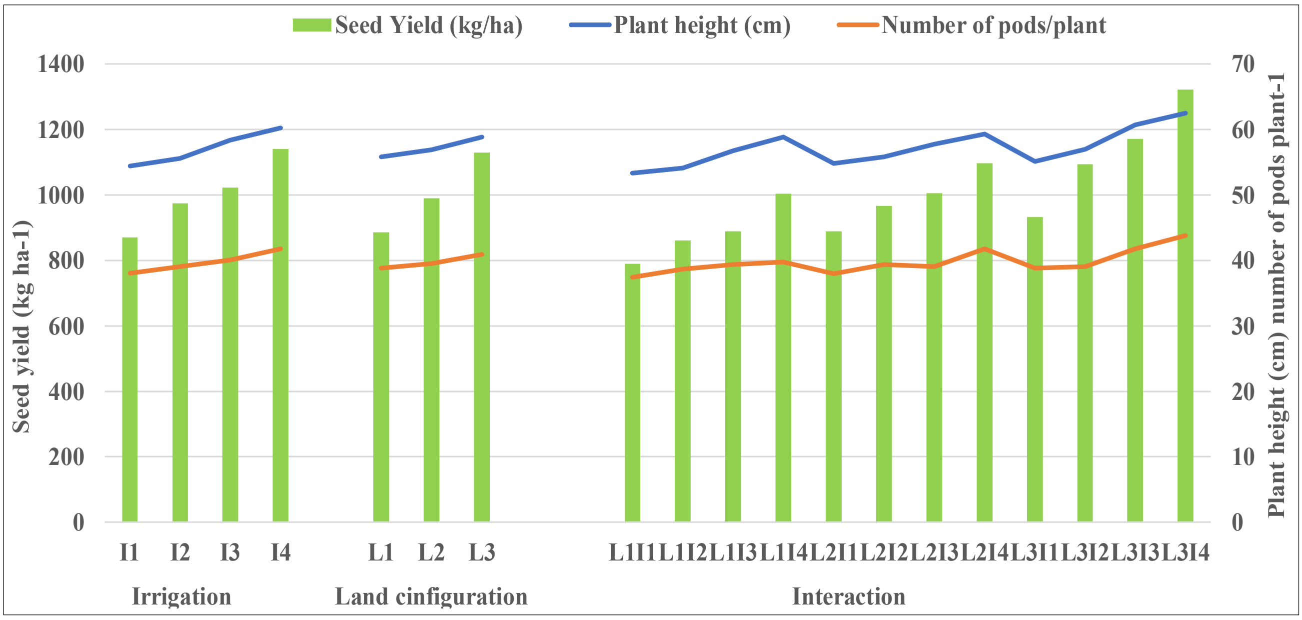

Fig 1: Growth, yield parameters and yield of greengram as influenced by land configuration and irrigation regimes.

Table 2: Resource use efficiency of greengram as influenced by land configuration and irrigation regimes at harvest.

I/L	IWUE (kg ha-mm^{-1})				Water productivity (kg m^{-3})				Nutrient use efficiency (kg seed kg nutrient^{-1})			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
I_1	2.79^{a-c}	2.96^{ab}	3.24^{a}	3.00^{a}	0.221^{b-e}	0.249^{a-c}	0.262^{a}	0.244^{a}	15.05^{e}	16.94^{de}	17.76^{c-e}	16.58^{c}
I_2	2.39^{c-e}	2.69^{b-d}	3.04^{ab}	2.71^{b}	0.206^{de}	0.232^{a-d}	0.261^{ab}	0.233^{ab}	16.39^{de}	18.42^{c-e}	20.84^{bc}	18.55^{b}
I_3	2.12^{e}	2.40^{c-e}	2.73^{b-d}	2.45^{b}	0.193^{de}	0.212^{c-e}	0.259^{ab}	0.221^{b}	16.94^{cd}	19.16^{b-d}	22.32^{ab}	19.48^{b}
I_4	2.09^{e}	2.29^{de}	2.75^{bc}	2.34^{c}	0.187^{e}	0.204^{de}	0.246^{a-c}	0.212^{c}	19.13^{b-d}	20.90^{bc}	25.16^{a}	21.73^{a}
Mean	2.35^{c}	2.58^{b}	2.94^{a}		0.202^{c}	0.224^{b}	0.257^{a}		16.88^{c}	18.86^{b}	21.52^{a}	
SV		S.Em. ±				S.Em. ±				S.Em. ±		
L		0.38				0.032				2.47		
I		0.63				0.055				4.79		
L × I		0.48				0.041				3.02		

nutrient^{-1}) over other land configurations. Whereas, flatbed recorded significantly the lowest NUE (16.8 kg seed kg nutrient^{-1}). This may be attributed to improved water and nutrient distribution across the bed due to the raised and sloping shape. This configuration might have promoted better root development, increased nutrient uptake and reduced nutrient losses through leaching, resulting in improved overall nutrient utilization (Patel *et al*., 2018).

Similarly, irrigation regimes also had a significant effect on NUE of greengram. Irrigating the crop at 0.90 IW/CPU ratio recorded significantly the highest NUE (21.73 kg seed kg nutrient^{-1}). Whereas irrigating the crop at critical growth stages recorded the lowest nutrient use efficiency (16.58 kg seed kg nutrient^{-1}) when compared with other irrigation regimes. This may be attributed to more frequent irrigations which helped to maintain optimal soil moisture levels, ensuring continuous water and nutrient supply to the plant's roots and resulting in increased growth, yield and NUE. These results are in harmony with the results of Idnani and Singh (2008) and Praharaj *et al.* (2016).

Among the various treatment combinations, irrigating the crop at 0.90 IW/CPE ratio under broad bed method recorded significantly the highest NUE (25.16 kg seed kg nutrient^{-1}) when compared with other treatment combinations. However, it was on par with irrigating the crop at 0.75 IW/CPE ratio under broad bed condition (22.32 kg seed kg nutrient^{-1}). Higher NUE under higher irrigation regimes is attribute to sufficient moisture availability underbroad bed furrow technique facilitating optimal soil moisture retention and aeration. This might have resulted in enhanced nutrient release, root growth and uptake by plants. However, the lowest NUE was recorded with irrigating the crop at critical growth stages under flatbed method (15.05 kg seed kg nutrient^{-1}). These results were similar to the results of Kantwa (2005) and Praharaj (2017).

Economics of greengram

The economics data (Table 3) depicted that, among the evaluated land configurations, broad bed furrow recorded highest gross return (₹ 86,323 ha^{-1}), net return (₹ 59,175 ha^{-1}) and benefit cost ratio (2.47). Further there was increase in gross returns, net returns and benefit cost with higher irrigation levels as there was higher seed yield. Similar findings were reported by Patel *et al.* (2016); Karikalan *et al.* (2020) and Sujatha *et al.* (2022).

The highest net returns (₹ 72,848 ha^{-1}) and benefit cost ratio (2.46) were recorded with L_3I_4 followed by L_3I_3 which was on par with each other. Whereas, the lowest net returns (₹ 34,335 ha^{-1}) and benefit cost ratio (1.27) was observed under L_1I_1. Even though there was higher cost of cultivation was incurred under higher irrigation regimes due to a greater number of irrigations, there was a positive impact of higher irrigation regimes on yield which resulted in higher net returns and benefit cost ratio

Table 3: Economics of greengram as influenced by land configuration and irrigation regimes.

I/L	Gross return (₹ ha^{-1})				Net return (₹ ha^{-1})				Benefit: Cost ratio			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
I_1	61290^{d}	68963^{d}	72297^{cd}	67517^{c}	34335^{f}	42007^{d-f}	45341^{c-f}	40561^{c}	1.27^{e}	1.56^{c-e}	1.68^{b-e}	1.50^{b}
I_2	66721^{d}	75001^{b-d}	84832^{a-c}	75518^{b}	38446^{ef}	46725^{c-f}	56556^{bc}	47242^{bc}	1.36^{e}	1.65^{b-e}	2.00^{a-c}	1.67^{b}
I_3	68973^{cd}	78015^{a-d}	85721^{a-c}	77570^{b}	40037^{ef}	49080^{b-e}	61955^{ab}	50357^{b}	1.38^{de}	1.70^{b-e}	2.14^{ab}	1.74^{ab}
I_4	77865^{a-d}	85090^{ab}	102444^{a}	88466^{a}	48270^{b-f}	55495^{b-d}	72848^{a}	58871^{a}	1.63^{c-e}	1.88^{b-d}	2.46^{a}	1.99^{a}
Mean	68713^{b}	76767^{b}	86323^{a}		40272^{c}	48327^{b}	59175^{a}		1.41^{c}	1.70^{b}	2.47^{a}	
SV	S.Em. ±				S.Em. ±				S.Em. ±			
L	11829.14				11390.36				0.11			
I	19480.98				19730.59				0.06			
L × I	12822.48				12145.04				0.12			

Means followed by the same letter (s) within a column are not differed significantly by DMRT (P = 0.05); SV- Source of variation.

M.S.P of greengram (*kharif* 2022) -₹ 7,755/q.

Vertical factor: Land configuration (L).

L_1: Flat bed sowing.

L_2: Ridge and furrows.

L_3: Broad bed furrows.

Horizontal factor: Irrigation regimes (I).

I_1: Irrigation at critical growth stages.

I_2: Irrigation at 0.60 IW/CPE ratio .

I_3: Irrigation at 0.75 IW/CPE ratio.

I_4: Irrigation at 0.90 IW/CPE ratio.

with higher irrigation regimes. These results are in consonance with the findings of Raza *et al.* (2012) and Sharma *et al.* (2019).

CONCLUSION

The above test results clearly showed that, broad bed furrow recorded significantly superior over rest of the land configurations with respect to growth, yield, resourse use efficiency and economics. Among different irrigation regimes evaluated, the higher irrigation regimes (0.90 IW/CPE ratio) produced higher growth, yield, NUE and net returns. Whereas, irrigation at critical growth stages and irrigation at 0.60 IW/CPE ratio higher and on par IWUE and WP which would save 37.5% and 27.0% irrigation water over 0.90 IW/CPE ratio, respectively. Though, the interaction effect of irrigation at 0.90 IW/CPE ratio and broad bed furrow produced significantly higher growth, yield, NUE and net returns. Irrigation at critical growth stages under broad bed method recorded maximum IWUE and WP. Hence, irrigating the summer greengram at critical growth stages under broad bed method can be recommended to farmers for sandy loam soil condition under water scare conditions. However, under assured irrigation situation summer greengram can be irrigated at 0.9 IW/CPE ratio under broad bed furrow system for realising higher yield and net returns in Punjab.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Ahlawat, I.P.S. and Gangaiah, B. D. (2010). Effect of land configuration and irrigation on sole and linseed (*Linum usitatissimum*) intercropped chickpea (*Cicer arietinum*). Indian Journal of Agricultural Research. 80(3): 250-253.

Akbar, G., Hamilton, G., Hussain, Z. and Yasin, M. (2007). Problem and potential raised bed cropping systems in Pakistan. Pakistan Journal of Water Resource. 11(1): 11-15.

Anonymous, (2022). Package of Practice for crops of Punjab-*Kharif* 2022. Punjab Agricultural University, Ludhiana (India). 84-86.

Anonymous, (2023). Annual Report-2022-23. Indian Institute of Pulse Research. Kanpur (India). 68-67.

Bhadre, C.K., Narkhede, W.N. and Desai, M.M. (2022). Effect of different land configuration, super absorbent and nutrient management on yield and economics of soybean (*Glycine max* L.)-Safflower (*Carthamus tinctorius*) cropping system. Legume Research. 45(12): 1540-1546. doi: 10.18805/LR-4319.

Choudhary, A.K. (2009). Role of phosphorus in pulses and its management. Indian Farmers Digest. 42(9): 32-34.

Gomez, K.A. and Gomez, A. (1984). Statistical Procedure for Agriculture Research. John Willey and Sons, New York.

Gull, M., Sofi, A.P., Mir, R.R., Ars, A. and Zargar, S.M. (2019). Productivity and resilience-based indices for identification of water stress resilient genotypes in cowpea (*Vigna unguiculata* L.). Indian Journal of Agricultural Research. 53(4): 391-397. doi: 10.18805/IJARe.A-5139.

Halli, H.M. and Angadi, S.S. (2019). Influence of land configuration on rain water use efficiency, yield and economics of cowpea (*Vigna unguiculata* L.) in maize-cowpea sequence cropping under rainfed condition of Northern Transitional Zone. Legume Research. 42(2): 211-215. doi: 10.18805/LR-3985.

Idnani, L.K. and Gautam, H.K. (2008). Water economization in summer greengram (*Vigna radiata*) as influenced by irrigation regimes and land configurations. Indian Journal of Agricultural Sciences. 78(3): 214-219.

Idnani, L.K. and Singh, R.J. (2008). Effect of irrigation regimes, planting and irrigation methods and arbuscular mycorrhizae on productivity, nutrient uptake and water use in summer greengram (*Vigna radiata* var radiata). Indian Journal of Agricultural Sciences. 78(1): 53-57.

Kantwa, S.R., Ahlawat, I.P.S. and Gangaiah, B. (2005). Effect of land configuration, post-monsoon irrigation and phosphorus on performance of sole and intercropped pigeonpea (*Cajanus cajan*). Indian Journal of Agronomy. 50(4): 278-280.

Karande, B.I., Patel, H.R., Patil, D.D., Yadav, S.B. and Vasani, M.J. (2019). Influence of irrigation levels and row spacings on yield and yield attributing characters of mungbean varieties (*Vigna radiata* L.) in middle Gujarat agro-climatic zone. International Journal of Current Microbiology and Applied Sciences. 8(2): 464-473.

Karikalan, N., Krishnaveni, S.A., Avudaithai, S. and Nithila, S. (2020). Effect of land configuration and nutrient management on yield and economics of greengram under sodic soil. International Journal of Current Microbiology and Applied Sciences. 9(12): 2125-2129.

Kaur, A. and Singh, V.P. (2006). Effect of planting methods, mulching and weed control on nutrient content and its uptake by pearlmillet under rainfed conditions. Crop Research. 31(3): 362-365.

Kumar, P.R., Santosh, M.S., Singh, A.K. and Bhatt, B.P. (2019). Impact of irrigation methods, irrigation scheduling and mulching on seed yield and water productivity of chickpea (*Cicer arietinum*). Legume Research. 44(10): 1247-1253. doi: 10.18805/LR-4188.

Marwein, Y., Ray, L.I. and Dey, J.K. (2017). Influence of mulch on depletion pattern of *in situ* soil moisture in rajma (kidney beans) crop system of Meghalaya. Journal of E Planet. 15(1): 55-60.

Patel, A.P., Patel, D.B., Chaudhary, M., Parmar P.N. and Patel, H.K. (2016). Influence of irrigation scheduling based on IW: CPE ratio and levels of sulphur on growth and yield of *rabi* greengram [*Vigna radiate* (L.) Mills]. Journal of Pure and Applied Microbiology. 10(1): 20-25.

Patel, T.U., Patel, A.J., Thanki, J.D. and Arvadiya, M.K. (2018). Effect of land configuration and nutrient management on greengram (*Vigna radiata*). Indian Journal of Agronomy. 63(4): 472-476.

Porpavai, S. and Nagarajan, M. (2022). Effect of land configuration and nutrient management methods on growth and yield of blackgram (*Vigna mungo*). Agricultural Science Digest. 42(1): 88-90. doi: 10.18805/ag.D-5245.

Praharaj, C.S., Singh, U., Singh, S.S. and Kumar, N. (2017). Micro-irrigation in rainfed pigeonpea–Upscaling productivity under Eastern Gangetic Plains with suitable land configuration, population management and supplementary fertigation at critical stages. Current Science. 95-107.

Praharaj, C.S., Singh, U., Singh, S.S., Singh, N.P. and Shivay, Y.S. (2016). Supplementary and life-saving irrigation for enhancing pulses production, productivity and water-use efficiency in India. Indian Journal of Agronomy, 61(4th IAC Special issue). 249-261.

Pramanik, S.C., Singe, N.B. and Singh, K.K. (2009). Yield, economics and water use efficiency of chickpea (*Cicer arientinum* L.) under various irrigation regimes on raised bed planting system. The Indian Journal of Agronomy. 54(3): 315-318.

Ramesh, T., Rathika, S., Nagarajan, G. and Shanmugapriya, P. (2020). Land configuration and nitrogen management for enhancing the crop productivity: A review. The Pharma Innovation Journal. 9(7): 222-230.

Raza, M.H., Sadozai, G.U., Baloch, M.S., Khan, E.A., Din, I. and Wasim, K. (2012). Effect of irrigation levels on growth and yield of mungbean. Pakistan Journal of Nutrition. 11(10): 974-977.

Sharma, S.K., Kumar, A., Singh, K. and Kumar, N. (2019). Effect of land configuration and weed management on yield and yield attributes of greengram (*Vigna radiata* L). Agricultural Science Digest. 39(4): 320-323. doi: 10.18805/ag.D-5025.

Selvan, S.S., Wahid, A., Patel, A., Kumar, V. and Sahu, P. (2021). Challenges in Indian agriculture. Agricultural Reviews. 42(4): 465-469. doi: 10.18805/ag.R-2103.

Singh, G., Joshi, V.K., Subhashchandra, Bhatnagar, A. and Dass, A. (2016). Spring maize (*Zea mays* L.) response to different crop establishment and moisture management practices in north-west plains of India. Research on Crops. 17(2): 226-230.

Singh, Y.P., Tomar, S.S., Singh, A.K. and Yadav, R.P. (2018). Nutrient management and irrigation scheduling effect on blackgram (*Vigna mungo*)-french bean (*Phaseolus vulgaris*) yield, economics, water productivity and soil properties. Journal of Soil and Water Conservation. 17(1): 58-64.

Sodavadiya, H.B., Naik, V.R. and Chaudhari, S.D. (2017). Effect of land configuration, irrigation and INM on growth, yield and water use efficiency of Indian bean (var. GNIB-21). International Journal of Current Microbiology and Applied Sciences. 6(7): 2624-2630.

Sujatha, H.T. Angadi, S.S., Yenagi, B.S., Hebsur, N.S. and Doddamani, M.B. (2022). Residual effect of irrigation levels and maize genotypes on the performance of succeeding blackgram (*Vigna mungo* L.) in maize-blackgram sequence cropping. Legume Research. 45(4): 1-6. doi: 10.18805/LR-4513.

Sujatha, H.T., Angadi, S.S., Yenagi, B.S. and Meena, R.P. (2023). Effect of drip irrigation regimes on growth, yield and economics of maize (*Zea mays*) genotypes. Indian Journal of Agricultural Sciences. 93(2): 163-168.

Vani, K.G., Mishra, P. and Devi, M. (2021). Dynamics of area substitution of pulses in India. Indian Journal of Agricultural Research. 56(3): 363-367. doi: 10.18805/IJARe.A-5711.