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Research Paper

Performance of chickpea (*Cicer arietinum*) under different land configurations, irrigation methods and schedules in sandy-loam soil

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ABSTRACT

A field study was carried out during the winter (*rabi*) season of 2017–18 at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, to study the effect of different land configurations, irrigation methods and schedules on growth, yield and economics of chickpea (*Cicer arietinum* L.). The results revealed that at maturity stage, plant height, branches/plant and 100-grain weight increased significantly in raised bed over flat-bed method of sowing. Plant dry-matter, pods/plant, grain weight/plant, grain and straw yields and net return and benefit: cost (B : C) ratio did not differ significantly due to land configuration treatment. Sprinkler irrigation resulted significant increase in growth characters (plant height, branches/plant and total plant dry-matter accumulation) and yield attributes (pods/plant, 100-grain weight and grain weight/plant), grain and straw yields and net return and B : C ratio as compared to check basin irrigation. Combination of sprinkler irrigation method and flat-bed sowing resulted in the highest grain yield (1,325 kg/ha). Under check basin irrigation, raised bed provided 7.8% higher grain yield than flat-bed method of sowing (1,083 kg/ha). Two irrigations at vegetative and pod-development stages resulted in significantly higher plant height, branches/plant, total dry-matter accumulation/plant, pods/plant, grain weight/plant, grain yield and higher net returns and B : C ratio than single irrigation at either stage.

***Key Words*:** Chickpea, Irrigation method, Irrigation schedule, Land configuration, Moisture

In India, winter (*rabi*) pulses hold a distinct position in total pulse production, among which chickpea occupies the largest share, having 9.55 million ha area, 9.94 million tonnes production and 1,041 kg/ha productivity in 2018–19 (Agricultural Statistics at a Glance, 2020). In northern plains of the country, the chickpea crop usually taken as a rainfed crop. However, in the past few decades change in rainfall pattern has been witnessed with changing climate, as a result, crop often suffers from low and erratic distribution of rainfall. Chickpea is sensitive to both excess and deficit moisture stresses. Deficit moisture affects germination, emergence and pod filling badly (Rahman *et al*., 2000). Chickpea may also face terminal drought leading to forced maturity. Excess soil moisture stimulates the incidence of foliar or root diseases. Shedding of pods, rotting of seed and hindrance in harvesting and threshing can occur at maturity (Rahman *et al*., 2000). Also, from flowering stage chickpea may revert back to vegetative stage due to its indeterminate habit. Thus both the extreme conditions of soil moisture lead to reduction in growth, development and yield of chickpea.

The best possible approach to cope up with erratic distribution of rainfall and water stress is to provide irrigation in controlled amount. Under conditions where flood irrigation facilities are available, a way to ensure controlled irrigation is by modifying the land configuration and raised-bed planting could be the most promising. In this approach, water moves to the root zone through lateral seepage as irrigation is applied in the furrows thereby limiting the water content in the root zone. In Langroya (Punjab), chickpea sown after rice on raised bed with 2 or 3 rows, outyielded flat-bed method of sowing significantly in sandy-loam soil (Sekhon *et al*., 2004). Sprinkler irrigation has the provision to apply controlled amount of irrigation, while in flood check basin at farm scale minimum 5–6 cm irrigation depth is feasible, which is usually detrimental to chickpea. In Punjab, chickpea plants turned yellow and die soon after flood irrigation due to excess moisture situation in the root zone effecting the yields (Sekhon *et al*., 2004),

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whereas, in sprinkler irrigation, the depth of irrigation can be controlled and sensitive crops like pulses are not likely to suffer. Singh *et al*., (2006) in silty clay loam soil of Patna (Bihar) found that, sprinkler irrigation gave significantly higher grain yield (1,562 kg/ha) over surface irrigation (1,331 kg/ha) in chickpea. The importance of giving irrigation would be less if not given at critical stages as irrigation at these stages, results in the maximum yield. Pre-flowering and pod development are critical stages of irrigation for chickpea. Depending on winter rains, productivity of chickpea increased appreciably when irrigation was applied at 50% flowering/pod-development stage or 2 irrigations at branching and pod-development stage (IIPR, 2009). Therefore, present experiment was conducted to study the effect of different land configurations, irrigation methods and scheduling at critical stages on growth, yield and economics of chickpea.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 2017–18 at the Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (29º N, 79.5ºE, 243.84 m above mean sea-level). The soil was neutral (*p*H 7.02) and sandy loam, containing high organic carbon (0.85%), low available nitrogen (218.5 kg/ha), high phosphorus (24.2%) and medium potassium (182.5 kg/ha). Field capacity and permanent wilting point moisture content were 18.5 and 6.4% respectively. During the crop season, only 13.6 mm rainfall was received. The experiment was laid out in factorial randomized block design with 3 replications. The treatments consisted of 2 land configurations (flat and raised bed), 2 irrigation methods (check basin and sprinkler irrigation) and 3 irrigation schedules (at vegetative, pod development and both stages). Chickpea variety ‘Pant Gram 186’ was sown @ 80 kg/ha at 30-cm-row spacing. Raised beds were prepared manually, using spade having 90 cm distance between centres of 2 furrows. Three rows were accommodated per bed so as to keep same plant population in both land configurations. Thinning was done 15 days after sowing to maintain plant-to-plant distance 8 ± 2 cm. Fertilizer (NPK fertilizer grade 12 : 32 : 16) @ 200 kg/ha was applied basal in all the treatments. Four sets of micro-sprinklers having diameter 4.0 m were placed per plot in a rectangular fashion. The irrigation depth was 5 cm in flat and 3.5 cm in raised bed under check-basin irrigation and 3 cm in sprinkler method for both the land configurations. The irrigations were scheduled as per treatments. Other cultural practices and plant-protection measures were followed as per recommendation.

Observations on growth attributes (plant height, branches per plant and total plant dry-matter accumulation), yield attributes (pods per plant, 100-grain weight and grain weight per plant), grain and straw yields were taken. Also soil moisture content of 0–15 cm layer 48 hours after irrigation, were recorded using gravimetric method. Based on net return and cost of cultivation in each treatment, benefit: cost (B : C) ratio was calculated.

RESULTS AND DISCUSSION

Growth and yield attributes

Land configuration**:** At maturity, due to land configurations, plant height and branches/plant were affected significantly. Raised-bed sowing method resulted in 3.1% higher plant height and 7.4% more branches/plant than flat-bed

Table 1. Effect of land configurations, irrigation methods and schedules on growth and yield attributes of chickpea

Treatment	Plant height (cm)	Branches/ plant	Dry-matter (g/plant)	Pods/ plant	100-grain weight (g)	Grain weight/ plant (g)
Land configuration						
Flat bed	38.3	6.8	23.20	12.62	16.88	3.21
Raised bed	39.5	7.3	23.44	13.27	17.82	3.25
SEm±	0.31	0.14	0.092	0.287	0.197	0.053
CD (P=0.05)	0.91	0.4	NS	NS	0.58	NS
Irrigation method						
Check basin	38.4	6.3	23.14	11.51	16.94	3.14
Sprinkler	39.4	7.8	23.50	14.38	17.76	3.32
SEm±	0.31	0.14	0.092	0.287	0.197	0.053
CD (P=0.05)	0.91	0.4	0.27	0.84	0.58	0.16
Irrigation schedule						
Vegetative	38.4	6.8	23.20	11.91	17.00	3.16
Pod development	37.3	6.8	22.66	11.12	17.47	3.02
Both stages	40.8	7.5	24.10	15.81	17.59	3.52
SEm±	0.38	0.17	0.112	0.352	0.241	0.065
CD (P=0.05)	1.12	0.5	0.33	1.03	NS	0.19

sowing (Table 1). The increase may be attributed to availability of more sunlight and better rhizospheric conditions in terms of availability of moisture and aeration. The mean moisture content 48 hours after irrigation in flat bed (15.82 %) was higher than raised bed (13.86%) (Fig. 1). The lower soil moisture in raised-bed sowing indicates that sensitive crops like chickpea will be more comfortable in raised bed than flat sowing. Joshi *et al*., (2020) also reported significant increase in plant height and number of branches in raised bed over flat-bed in chickpea, and was attributed to aggregate effect of optimum moisture and air regime. The dry-matter accumulation/plant was improved in raised-bed sowing but found to be non-significant (Table 1). The increased dry matter might be the result of higher plant height and number of branches/plant in raised-bed sowing compared to flat-bed sowing. Raised-bed sowing method recorded significantly higher 100-grain weight (5.6%) than flat-bed sowing (Table 1). Other parameters, viz. pods/plant and grain weight/plant were also improved under raised-bed sowing, but the increase was not significant (Table 1). The increase in yield attributes in raised-bed may be owing to higher dry-matter accumulation/plant which had supplied more photosynthates for development.

Irrigation method: All the growth and yield attributes got significantly influenced by irrigation methods and sprinkler-irrigation method outperformed check-basin irrigation method (Table 1). Under the sprinkler irrigation, the increment in plant height and branches/plant was 2.6 and 23.8%, respectively, when compared to check-basin irrigation. Under sprinkler irrigation, controlled and uniform supply of water might have positively influenced the micro-climate of the crop and allowed efficient use of water and nutrients by crop plants. With respect to soil moisture, when check-basin irrigation was applied, the average soil moisture was 16.74% 48 hours after irrigation against 12.94% in sprinkler method, thus chickpea being highly sensitive to moisture stress might have suffered due to excess moisture in the root zone under check-basin irrigation (Fig. 1). Additionally, under check-basin irrigation the soil particles might get settled down firmly thereby reducing the air flow in rhizosphere and thus, causing stunted growth of crop plant. Further, sprinkler irrigation resulted 24.9, 4.8 and 5.7% (significantly) higher pods/plant, 100-grain weight and grain weight/plant, respectively, over check-basin irrigation owing to the adequate supply of moisture which might have resulted in significantly higher nodulation, higher nutrient uptake, enhanced dry-matter accumulation (up to 1.56%) and in turn supplied higher photosynthates towards sink. Singh *et al*., (2017) reported significantly higher growth and yield attributes in sprinkler irrigation over check basin irrigation in chickpea.

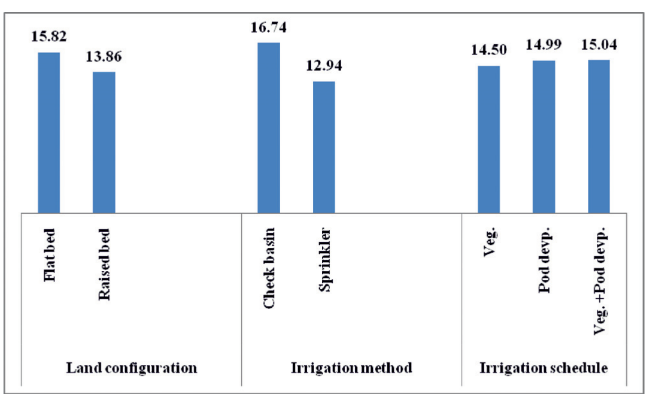

Fig. 1. Mean per cent soil-moisture content (0–15 cm) 48 hours after irrigation under different land configurations, irrigation methods and schedules (Veg., Vegetative; devp., development)

Irrigation schedule: Except 100-grain weight, remaining growth and yield attributes were affected significantly by irrigation schedules (Table 1). At maturity, 2 irrigations at vegetative and pod-development stages recorded significantly higher plant height, number of branches and total plant dry-matter/plant than single irrigation at either stage owing to the combined effect of 2 irrigations which maintained better moisture throughout the growing period that in turn might have helped the plant to function physiologically well. Patel *et al*., (2016) also reported that, 2 irrigations at branching and pod-development stages in chickpea resulted in higher growth attributes over single irrigation at either stage. Irrigations at vegetative and pod-development stages resulted in 32.7 and 42.2% higher pods/plant and 11.4 and 16.6% higher grain weight/plant, respectively, over single irrigation at vegetative and single irrigation at pod-development stage. This may be attributed to availability of optimum moisture (15.04%) throughout growing period which might have increased the nutrient uptake and enhanced dry-matter accumulation, thus leading to greater synthesis, translocation and assimilation of photosynthates in 2 irrigations treatment (Fig. 1). The difference in growth and yield attributes among single irrigations was at par with each other. Singh *et al.,* (2004) also reported significant increase in growth and yield attributes when 2 irrigations were applied at pre-flowering and pod-development stages over single irrigation at pre-flowering stage.

Yield and harvest index

Land configuration: There was no significant difference in grain and straw yield of chickpea between 2 land configurations. As a result, they did not exhibit significant impact on harvest index as well (Table 2). Only 13.6 mm rainfall occurred during the crop-growing season; as a result, the flat-bed sowing performed equivalent to raised-bed sowing.

Irrigation method: Grain and straw yields were significantly higher in sprinkler irrigation (1,296 and 2,310 kg/ha, respectively) than check-basin irrigation (1,125 and 2,178 kg/ha respectively). The improvement may be credited to higher growth and yield attributes found in sprinkler irrigation. As a result, harvest index was significantly higher in sprinkler irrigation (35.8) than check-basin irrigation (34.0) (Table 2). Singh *et al*., (2017) reported lower yields of chickpea under check-basin irrigation.

Irrigation schedule: Irrigations at vegetative and pod-development stages resulted in 17.15 and 22.10% significantly higher grain yield than single irrigation either at vegetative or pod-development stage respectively (Table 2). Two irrigations at critical stages resulted in better supply of moisture, thereby prevented the chickpea crop from prolonged stress and consequently the growth and yield attributes were improved significantly and ultimately yield. However, irrigations at both the stages ensued significantly higher straw yield (2335 kg/ha) than irrigation at pod-development stage. Therefore, irrigation at vegetative and pod-development stages resulted in significantly highest harvest index (HI) owing to combined effect of significantly highest grain and straw yield under this treatment (Table 2). Higher HI with 2 irrigations over single irrigation reveals that increase in economic yield was more than increase in straw yield. It may be attributed to better partitioning of photosynthates owing to availability of more moisture. Single irrigation at vegetative stage was statistically at par with single irrigation at pod-development stage. Chourasiya *et al*., (2016) found that, irrigation in chickpea at branching and pod-development stages enhanced seed yield, straw yield and harvest index significantly over single irrigations at either stage owing to availability of moisture at critical stages which favourably impacted yield

Table 2. Yield and harvest index of chickpea as influenced by land configurations, irrigation methods and schedules

Treatment	Yield (kg/ha)		Harvest index
	Grain	Straw	(%)
Land configuration			
Flat bed	1,204	2,251	34.7
Raised bed	1,217	2,237	35.2
SEm±	23.1	34.3	0.39
CD (P=0.05)	NS	NS	NS
Irrigation method			
Check basin	1,125	2,178	34.0
Sprinkler	1,296	2,310	35.8
SEm±	23.1	34.3	0.39
CD (P=0.05)	68	101	1.1
Irrigation schedule			
Vegetative	1,160	2,239	34.1
Pod development	1,113	2,158	34.0
Both stages	1,359	2,335	36.7
SEm±	28.4	42.0	0.47
CD (P=0.05)	83	123	1.4

attributes and ultimately the yield and harvest index.

Interaction effect: There was no significant difference in grain yield of chickpea between 2 land configurations under check-basin irrigation. In raised bed, sprinkler irrigation (1267 kg/ha) showed statistically superior grain yield as compared to check-basin irrigation (1167 kg/ha) and the difference may be attributed to controlled and uniform application of water in sprinkler irrigation. The grain yield of sprinkler irrigation in flat bed (1325 kg/ha) was statistically at par with sprinkler irrigated raised bed (1267 kg/ha) and was statistically superior to all other treatment combinations (Table 3).

Table 3. Interaction effect of land configurations and irrigation methods on grain yield (kg/ha) of chickpea

Land configuration	Irrigation method	
	Check basin	Sprinkler
Flat bed	1,083	1,325
Raised bed	1,167	1,267
SEm±	32.7	
CD (P=0.05)	96	

Economics

Land configuration: The cost of cultivation was higher in raised bed (₹30,403/ha) than flat bed (₹30,120/ha) owing to more time taken by tractor in making raised beds. The net return and B : C ratio were not affected significantly by land configurations, which may be due to non-significant difference in grain and straw yields between 2 land configurations (Table 4).

Irrigation method: The cost of cultivation was slightly higher in sprinkler irrigation (₹30,495/ha) than check-basin irrigation method (₹30,028/ha) owing to additional cost of installation of sprinklers. The net returns were significantly higher in sprinkler irrigation (₹27,226/ha) than check-basin irrigation (₹20,130/ha) owing to significantly higher grain and straw yields in sprinkler irrigation. As a result, B : C ratio was higher with sprinkler method (0.89) than check-basin method (0.67) (Table 4).

Irrigation schedule: The cost of cultivation was higher in 2 irrigations at vegetative and pod development stage than single irrigation at either stage due to additional cost of irrigation. Irrigations at vegetative and pod-development stages resulted in significantly highest net returns and B : C ratio (₹29636 and 0.96 respectively) as compared to single irrigation at vegetative (₹21,734 and 0.73 respectively) or pod-development stage (₹19,665 and 0.66 respectively). This shows that the yield advantage in terms of net returns was more than the cost incurred on application of additional irrigation (Table 4). Chourasiya *et al*., (2016) also revealed that the maximum net

Table 4. Effect of land configurations, irrigation methods and schedules on economics of chickpea

Treatment	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Land configuration			
Flat-bed	30,120	23,534	0.78
Raised-bed	30,403	23,822	0.78
SEm±	–	1,024	0.034
CD (P=0.05)	–	NS	NS
Irrigation method			
Check basin	30,028	20,130	0.67
Sprinkler	30,495	27,226	0.89
SEm±	–	1,024	0.034
CD (P=0.05)	–	3,005	0.10
Irrigation schedule			
Vegetative	29,970	21,734	0.73
Pod development	29,970	19,665	0.66
Both stages	30,845	29,636	0.96
SEm±	–	1,255	0.041
CD (P=0.05)	–	3,681	0.12

returns and B : C ratio were obtained when irrigation in chickpea was given at branching and pod-development stages.

Based on study, it can be concluded that in sandy-loam soil and in low rainfall season, chickpea can be sown in flat bed and irrigated by sprinkler method. For, check-basin irrigation method, raised-bed sowing was found better. Two irrigations at vegetative and pod-development stages are essential to achieve higher grain yield of chickpea.

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