International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 1867-1870

Received: 22-05-2018
Accepted: 29-06-2018

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Productivity and economic efficiency of chickpea as influenced by land configurations, irrigation scheduling and weed management

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Abstract
A field investigation was conducted during *Rabi* 2013-14 and 2014-15 at J.N.K.V.V, Jabalpur to study the productivity and economic efficiency of chickpea as influenced by land configurations, irrigation scheduling and weed management. The treatments comprised 3 land configurations (Flat bed, Broad bed furrow, Ridge-furrow); 3 irrigation schedules (Irrigation at branching, Irrigation at pod development, Irrigation at branching and pod development) as main plot treatments and 3 weed management (Weedy Check, Hand weeding twice at 25 and 50 DAS, Pendimethalin @1.0 kg a.i.ha^{-1} as pre emergence) as sub-plot treatments. The experiment was laid out in a Split plot design with 3 replications. Ridge-furrow method resulted in significantly higher seed yield (1512.33 and1743.01 kg ha^{-1}), Production efficiency of seed (12.60 and 14.53 kg ha^{-1} day^{-1}), economic efficiency (RS. 366.59 and 643.25 ha^{-1} day^{-1}), partial factor productivity of N and K (75.62 and 87.15 kg ha^{-1}) and P (25.21 and 29.05kg ha^{-1}) over flatbed and broad bed furrow. Irrigation at branching and pod development gave appreciably higher seed yield of 1318.33 and 1457.48 kg ha^{-1}, Production efficiency of Seed (10.99 and 12.15 kg ha^{-1} day^{-1}), economic efficiency (Rs. 291.81 and 501.44 ha^{-1} day^{-1}), partial factor productivity of N and K (74.17 and 81.89 kg ha^{-1}) and P (24.72 and 27.30 kg ha^{-1}) over rest of the irrigation scheduling. Hand weeding twice registered higher seed yield (1719.56 and 1969.24 kg ha^{-1}), Production efficiency of seed (14.33 and 16.41 kg ha^{-1} day^{-1}), economic efficiency (Rs. 419.52 and 727.18 ha^{-1} day^{-1}), partial factor productivity of N and K (85.98 and 98.46kg ha^{-1}) and P (28.66 and 32.82 kg ha^{-1}) over weedy check and pendimethalin @1.0 kg a.i.ha^{-1} PE but economic efficiency with pendimethalin @1.0 kg a.i.ha^{-1} PE (Rs. 413 ha^{-1} day^{-1}) was at par to hand weeding twice.

Keywords: Land configuration, irrigation schedule, weed management, yield, economics

Introduction
Chickpea (*Cicer arietinum* L.) is the prime important winter pulse crop of India. It contributes 47% of total pulse production and about 40% of pulse growing area in the country. India accounts for over 60% of global chickpea production. It has unique ability of biological nitrogen fixation, deep root system and mobilization of insoluble nutrients. It improves physical, chemical and biological environment of soil, it can arrest the declining trend in productivity of cereal-cereal cropping system. This crop has emerged as a viable option to improve soil health, conserve the natural resources and sustain the agriculture productivity. The seed contains 21 % protein, 61.5 % carbohydrates, 4.5 % fat and also rich in calcium, iron and niacin. Soaked seeds and husk are fed to horses and cattle as concentrate and roughages, respectively. Malic and oxalic acids collected from green leaves are prescribed for intentional disorders. Straw forms an excellent fodder for cattle. Out of the several factors responsible for higher productivity of chickpea land preparation, water and weed management are more crucial and assumes great importance for successful cultivation of chickpea. Ridge/Broad Bed Furrow sowing is gaining popularity in case of heavy soils. The implement used for sowing is multi-crop ridger. Chickpea crop experiences moisture stress during long dry spells and also suffers terminal moisture stress at pod formation stage. Ridge- furrow method not only facilitates moisture conservation but also drainage of excess water in black soils. Ridge-furrow sowing in chickpea using multi crop ridger resulted in yield increase of 25.6% compared to conventional sowing (10.0 q ha^{-1}). (Rao *et al*., 2017) [6]. Flood irrigation in flat bed sowing in heavy soils badly damages the chickpea crop due to water stagnation. If the chickpea is sown on ridge-furrow or broad bed furrow method, less irrigation water is required to crop under water stress conditions and improves seed size and grain yield (IIPR, 2012) [3].

Chickpea is predominantly grown on residual soil moisture as is evident from the fact that of the total area in the country, only 1.96 million ha (28.3%) is irrigated (FAI, 2005) [2]. The moisture stress at some of the critical stages of growth often leads to its lower productivity. Weeds are a serious constraint in increasing production and easy harvesting in chickpea. It is a poor competitor to weeds because of slow growth rate and limited leaf area development at early stage of crop growth and establishment (Solh and Pala, 1990) [8]. Keeping the above facts in view, the present investigation was undertaken with the object to find out suitable land configuration, irrigation schedule and weed management for economical production of chickpea.

Materials and Methods

The present experiment was conducted during *rabi* seasons of 2013-14 and 2014-15 at Agronomy Research Farm, College of Agriculture, JNKVV, Jabalpur (M.P.). The treatments comprised three land configuration *viz.*, Flat bed (M_1), Broad bed furrow (M_2), Ridge- furrow (M_3); three irrigation schedules *viz.*, Irrigation at branching (I_1), Irrigation at pod development (I_2), Irrigation at branching and pod development (I_3) as main plot treatments and three weed management *viz.*, Weedy check (W_0), Hand weeding twice at 25 and 50 DAS (W_1) and Pendimethalin @1.0 kg a.i. ha^{-1}PE (W_2), as sub-plot treatments were laid out in split plot design with three replications. Chickpea variety 'JG 322' was sown on 15th December 2013 and 10th December 2014 at seed rate of 80 kg ha^{-1} with different land configuration methods (*viz*., flat bed, broad bed and ridge-furrow) and harvested on 15th April 2014 and 10th April 2015. The recommended doses of fertilizer 20: 60: 20 N: P_2O_5: K_2O kg ha^{-1} was applied uniformly. Entire quantities of NPK were applied as basal at the time of sowing. Value of Critical differences (CD) was calculated only for those characters, which were found significant at 5% level of significance. The appropriate statistical procedures of 'Split-Plot Design' given by Steel and Torrie,1960 [9] were followed for the data analysis. Imposition of treatments for Land configurations, Flatbed (M_1): Tractor driven normal seed drill adjusted at 30 cm row spacing was used for sowing of the seed under this method. Broad Bed Furrow (M_2): Tractor driven broad bed furrow calibrated at 30 cm row spacing was used for sowing of the seed. Ridge-furrow (M_3): Tractor driven Ridge-Furrow seed drill with calibrated at 30 cm row spacing was used for sowing of the seed. For irrigation schedules, Irrigation at branching (I_1): Irrigation was done when the crop reached at 50 per cent branching stage (about 40 DAS). Irrigation at pod development (I_2): Irrigation was applied when the crop reached at pod development stage (about 80 DAS). Irrigation at branching and pod development (I_3): Irrigations were given when the crop reached at branching (About 40 DAS) and pod development (about 80 DAS) stages. Each irrigation was given by flood method of irrigation and a measured quantity of water in each plot was applied by using partial flume of 7.5 cm thought width. For weed management, Hand weeding twice (W_1): at 25 and 50 DAS were performed to control weeds manually with the help of Khurpi. Pendimethalin (Stomp 30 EC) was applied @ 1.0 kg a.i. ha^{-1} as pre emergence at 2 DAS (W_2). Spraying of the herbicide was done with Knapsack spryer using flat-fan nozzle. No any weed control method was used in weedy check plots.

Different efficiencies were computed by using the following formulae

$$\text{Seed production efficiency (Kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Total seed yield produce (kg ha}^{-1}\text{)}}{\text{No. of days required in production}}$$

$$\text{Biomass production efficiency (Kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Total biomass produce (kg ha}^{-1}\text{)}}{\text{No. of days required in production}}$$

$$\text{Partial factor productivity (Kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Seed Yield (kg ha}^{-1}\text{)}}{\text{Quantity of partial factor}}$$

Results and Discussion

Effect on seed yield

Perusal of the data (Table-1) indicates that among the different land configurations, ridge-furrow sowing resulted in significantly higher seed yield (1512.33 and1743.01 kg ha^{-1}) which was 10.82,15.73 and 19.78,29.38 per cent more in comparison to broad bed furrow and flat-bed methods, respectively during both the years. This might be due to better porosity and availability of soil moisture which helped in better growth and development of the crop. These similar findings are in collaboration with the results of Munirathnam and Sangita, 2009[4], Tumbare and Bhoite, 2003 [10]. Irrigation at branching and pod development gave appreciably higher seed yield of 1483.33 and 1637.83 kg ha^{-1} and the increase in seed yield 11.12, 11.01 and 14.22, 17.73 per cent than that of irrigation at pod development and at branching alone in the respective years. The higher yield under Irrigation at branching and pod development was owing to availability of soil moisture at branching as well as pod development which enhanced availability of nutrients resulting in higher values of yield attributes ultimately resulting in higher seed yield. Similar results were also advocated by Patel *et al*., 2009 [5]. Among the different weed control treatments, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} PE resulted in 52.17 and 55.35 per cent more seed yield (1592.74 kg ha^{-1}) over weedy check. However, hand weeding twice registered markedly higher seed yield of 1719.56, 1969.24 kg ha^{-1}being 55.70 and 61.23 per cent more in comparison to control (761.81 kg and 763.46 ha^{-1}) during years of experimentation. The increase in seed yield due to application of Pendimethalin @ 1.0 kg a.i. ha^{-1} or hand weeding twice was attributed to effective control of weeds which helped the crop by increment in the availability of nutrients and soil moisture which caused enhancement in yield attributes and finally seed yield. These results are in agreement with the findings of Singh *et al*., 2008 [7].

Effect on production efficiency of seed and biomass

The data in Table-1 reveal that, ridge-furrow sowing gave significantly higher seed production efficiency (12.6 and 14.53 kg ha^{-1}day^{-1}) than that of Broad bed furrow (11.24 and 12.24 kg ha^{-1}day^{-1}) and Flatbed (10.11 and 10.26 kg ha^{-1} day^{-1}) during both the years. Different land configurations exhibited almost similar trend in biomass production efficiency (BPE) as observed in case of seed production efficiency (SPE). These findings are in collaboration with the results of Chourey, 2012 [1]. Irrigation at branching and pod development registered significantly higher seed production efficiency (12.36 and 13.65 kg ha^{-1}day^{-1}) as compared to Irrigation at pod development (10.99 and 12.15 kg ha^{-1}day^{-1}) and Irrigation at branching (10.60 and 11.23 kg ha^{-1}day^{-1}) during the respective years. The variations in seed production efficiency between I_1-I_2 or I_3 were also significant. BPE indicated similar influence due to irrigation schedules as

noted in SPE. Similar results were also advocated by Chourey, 2012 [1]. The efficiency was appreciably maximum under hand weeding twice (14.33 and 16.41 Kg ha^{-1} day^{-1}) than application of Pendimethalin @1.0 kg a.i./ha.PE (13.27 and 14.25 Kg ha^{-1} day^{-1}) and Weedy Check (6.35 and 6.36 Kg ha^{-1} day^{-1}) which had the minimum seed production efficiency in both the years. Various weed management exhibited almost similar trend in biomass production efficiency (BPE).These results are in agreement with the findings of Singh *et al*., 2008 [7].

Effect on economic efficiency

The data (Table-1) reflected that significantly higher economic efficiency (Rs. 366.59 and 643.25 $ha^{-1}day^{-1}$) was noted under ridge-furrow sowing which exhibited its superiority over rest of the land configurations during both the years. It was also noticed that broad bed furrow sowing ranked second in respect of economic efficiency was also markedly higher (Rs. 302.28 and 505.40 $ha^{-1}day^{-1}$) than that of flatbed (Rs. 249.35 and 385.80 $ha^{-1}day^{-1}$).Among the various irrigation schedules, Irrigation at branching and pod development gave appreciably higher economic efficiency of Rs. 350.74 and 584.89 $ha^{-1}day^{-1}$ in comparison to irrigation at branching and pod development separately during both the years. As regard the weed management treatments, hand weeding twice exhibited its superiority in recording appreciably higher economic efficiency (Rs. 419.52 and 727.18 $ha^{-1}day^{-1}$) than that of weedy check in the respective years but at par with Pendimethalin @1.0 kg a.i. ha^{-1} PE (W_2) during first year. It is also apparent that the later treatment (i.e. W_2) also resulted in markedly higher seed yield in comparison to weedy check.

Effect on Partial Factor Productivity (PFP) of N, P and K

The data (Table-2) indicates that among different land configuration, Ridge-furrow gave significantly maximum PFP of N (75.62 and 87.15 kg ha^{-1}) as compared to Flatbed and Broad bed and furrow in the respective years. The PFP was minimum under flatbed. Almost similar trends were observed as regard in PFP of P and K. In case of irrigation schedule, irrigation at branching and pod development registered higher PFP of N (74.17 and 81.89 kg ha^{-1}) as compared to Irrigation at branching and pod development separately The PFP was minimum with irrigation at branching. Irrigation schedules exhibited almost similar results on PFP of P and K during both the years.Hand weeding at 25 and 50 DAS resulted in significantly maximum PFP of N (85.98 and 98.46 kg ha^{-1}) as compared to weedy check and Pendimethalin @1.0 kg a.i. ha^{-1}.PE The weed management treatments exerted almost similar effect on PFP of P and K during first and second year.

Table 1: Seed yield, production and economic efficiency as influenced by different treatments

Treatment	Seed yield (kg ha^{-1})		Production Efficiency (Kg ha^{-1} day^{-1})				Economic efficiency (Rs. $ha^{-1}day^{-1}$)	
			Seed		Biomass			
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Land Configurations								
M_1-Flat Bed	1213.15	1230.90	10.11	10.26	35.00	35.76	249.35	385.80
M_2-Broad Bed Furrow	1348.63	1468.79	11.24	12.24	38.33	42.05	302.28	505.40
M_3-Ridge-Furrow	1512.33	1743.01	12.60	14.53	42.39	49.26	366.59	643.25
SEm±	29.71	32.99	0.25	0.27	0.85	0.96	12.30	17.15
CD (p=0.05)	89.07	98.91	0.74	0.82	2.55	2.88	36.88	51.43
Irrigation Schedules								
I_1-Irrigation at branching	1272.44	1347.39	10.60	11.23	36.77	39.20	275.67	448.12
I_2-Irrigation at pod development	1318.33	1457.48	10.99	12.15	37.36	41.61	291.81	501.44
I_3-Irrigation at branching and pod development	1483.33	1637.83	12.36	13.65	41.60	46.27	350.74	584.89
SEm±	29.71	32.99	0.25	0.27	0.85	0.96	12.30	17.15
CD (p=0.05)	89.07	98.91	0.74	0.82	2.55	2.88	36.88	51.43
Weed Management								
W_0-Weedy Check	761.81	763.46	6.35	6.36	22.02	22.28	86.16	167.23
W_1-Hand weeding twice at 25 and 50 DAS	1719.56	1969.24	14.33	16.41	48.11	55.50	419.52	727.18
W_2-Pendimethalin @1.0 kg a.i.ha^{-1}.PE	1592.74	1710.00	13.27	14.25	45.60	49.29	412.53	640.05
SEm±	20.93	22.55	0.17	0.19	0.57	0.62	8.57	11.55
CD (p=0.05)	60.07	64.73	0.50	0.54	1.65	1.79	24.59	33.17

Table 2: Partial factor productivity (PFP) of Nitrogen, Phosphorus and Potassium as influenced by different treatments

Treatment	Partial factor productivity (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Land Configurations						
M_1-Flat Bed	60.66	61.54	20.22	20.51	60.66	61.54
M_2-Broad Bed Furrow	67.43	73.44	22.48	24.48	67.43	73.44
M_3-Ridge-Furrow	75.62	87.15	25.21	29.05	75.62	87.15
SEm±	1.49	1.65	0.50	0.55	1.49	1.65
CD (p=0.05)	4.45	4.95	1.48	1.65	4.45	4.95
Irrigation Schedules						
I_1-Irrigation at branching	63.62	67.37	21.21	22.46	63.62	67.37
I_2-Irrigation at pod development	65.92	72.87	21.97	24.29	65.92	72.87
I_3-Irrigation at branching and pod development	74.17	81.89	24.72	27.30	74.17	81.89
SEm±	1.49	1.65	0.50	0.55	1.49	1.65
CD (p=0.05)	4.45	4.95	1.48	1.65	4.45	4.95
Weed Management						
W_0-Weedy Check	38.09	38.17	12.70	12.72	38.09	38.17

W_1-Hand weeding twice at 25 and 50 DAS	85.98	98.46	28.66	32.82	85.98	98.46
W_2-Pendimethalin @1.0 kg ha^{-1}.PE	79.64	85.50	26.55	28.50	79.64	85.50
SEm±	1.05	1.13	0.35	0.38	1.05	1.13
CD (p=0.05)	3.00	3.24	1.00	1.08	3.00	3.24

Conclusion

Based on the two years result it could be concluded that ridge-furrow method with two irrigations at branching and pod development stages as well as application of Pendimethalin @1.0 kg a.i.ha^{-1}as pre emergence results in higher seed yield, production efficiency of seed and biomass, economic efficiency and partial factor productivity of NPK under sandy clay loam soil of Jabalpur (M.P.)

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