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Growth, Productivity and Economics of Kabuli Chickpea (*Cicer arietinum* L.) Genotypes in Response to Seed Rate in Northern India

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A B S T R A C T

Seed is a basic and costly input in agriculture. Genotypes of a crop varying in seed size and growth behaviour may differ in optimal seed rate for realizing high grain yields. Field experiments were conducted for three years at Punjab Agricultural University, Ludhiana, India to study the growth, productivity and economics of *kabuli* chickpea genotypes in response to seeding rate. On the basis of three-year mean, seeding rate of 110 kg ha^{-1} provided the highest grain yield (1491 kg ha^{-1}), followed by 130 kg ha^{-1} (1415 kg ha^{-1}) and 90 kg ha^{-1} seed rate (1196 kg ha^{-1}). Among genotypes, BG 1053, GLK 22117, GLK 24092 and GLK 25132 were high yielders. Higher grain yields were produced by BG 1053, GLK 22117, GLK 24092 and GLK 25132 with a seed rate of 110 kg ha^{-1}, whereas GLK 23008 and GLK 23035 yielded higher at 130 kg ha^{-1} seed rate. A seed rate of 110 kg ha^{-1} provided with the highest gross returns, net returns and B:C ratio. Genotypes differed in days to 50% flowering (88-110 days) and days to maturity (136-163 days).

Introduction

Chickpea (*Cicer arietinum* L.) is an important grain legume in the world. During 2014, globally it was grown on 13.98 million ha area, with the total production of 13.73 million tonnes (FAOSTAT, 2017) and average productivity of 982 kg ha^{-1}. The important chickpea growing countries are India, Turkey, Pakistan, Australia, Myanmar and Ethiopia. In many countries, the average chickpea yields are very low. Many biotic and abiotic constraints limit chickpea yield (Sekhon *et al.*, 1994, 2002, 2004; Virk *et al.*, 2005; Singh *et al.*, 2011, 2016; Sharma and Singh, 2013; Singh, 2016). Major biotic constraints include Ascochyta blight caused by *Ascochyta rabiei*, Botrytis grey mould caused by *Botrytis cinerea* and gram pod borer *Heliothis armigera* whereas major abiotic factors are very low as well as very high temperatures, moisture stress, salinity etc.

Kabuli chickpea is one of the two types of chickpea (*desi* and *kabuli*) which has cream-coloured large seed with a thin seed coat, in contrast to *desi* type which has darker-coloured small-sized seed with a thick seed coat. In *kabuli* chickpea, a plant population of

40-45 plants m^{-2} provides high grain yields (Gan *et al.,* 2003b). Inadequate plant population is one of the important factors responsible for poor grain yields of chickpea (Nagarajaiah *et al.*, 2005; Bavalgave *et al.*, 2009). Poor plant stand could be due to use of low seed rate, poor quality seed, insufficient moisture at sowing, plant mortality due to various diseases or salinity or moisture stress, etc. Adequate plant population may be maintained by using good quality optimum seed rate. However, seed is a costly input and need to be used judiciously as it involves lot of money. Further, as chickpea is generally grown under one or the other stress conditions on marginal soils, the risk of the crop failure discourages farmers to use costly inputs including the use of high seed rate.

Rice (*Oryza sativa*)–wheat (*Triticum aestivum*) is an important cropping system in northern India, especially in the states of Punjab, Haryana and Western Uttar Pradesh. Though this cropping system proved to be very good in terms of high yields, ensuring food security and high income to the farmers yet it has its own demerits including the lowering of ground water table (Hira, 2009). Underground water has to be used judiciously for sustaining crop production. Diversifying rice–wheat cropping system with some less water requiring crops is the need of the day. At present levels of the yields and prices offered, no other crop than rice can be taken by the farmers as rice is a stable crop, with high yield levels, good minimum support price and no difficulty in procurement by the government and other agencies. So replacement of rice with any other crop during the rainy (*kharif*) season seems to be difficult. However, during winter (*rabi*) season *kabuli* chickpea has the potential to provide with the high income to farmers due to its good price in the market and, therefore, it could replace some area under wheat. *Kabuli* chickpea has lower water requirement than wheat and it is used by the people in a variety of forms in their diet.

The optimum seed rate for *desi* chickpea genotypes is 45 kg ha^{-1} whereas for *kabuli* types it is 92.5 kg ha^{-1} (PAU, 2016). Further, seed rate requirement varies with the seed size (Singh and Sekhon 2006; Sekhon and Singh, 2008; Sheoran *et al.,* 2008). Bold seeded *kabuli* chickpeas are used for table purpose. Therefore, there is a need to develop bold seeded *kabuli* chickpea genotypes. As these bold seeded genotypes may require high seed rate for high yields, there was a need to study their optimum seed rate requirements. Experiments were, therefore, conducted to study the response of *kabuli* chickpea genotypes to seed rate.

Materials and Methods

Site characterization

The experiments were conducted during winter (*rabi*) season in 2005-06, 2006-07 and 2007-08 at Punjab Agricultural University, Ludhiana, India. Ludhiana is situated at 30°56'N, 72°52'E, altitude 247 m. The soil of the experimental site was loamy sand, having pH 8.2, testing low in organic carbon (0.30%), medium in available phosphorus (15.2 kg/ha), and medium in available potash (225.5 kg/ha). The weekly mean minimum and maximum temperatures recorded at the Meteorological Observatory of the Punjab Agricultural University, Ludhiana, India are presented in figure 1 and weekly total rainfall data recorded during the crop growing period are presented in table 1. The minimum weekly mean temperature was very low from standard week 50 (mid December) to standard week 7 (mid February) during all the three years of the study and it was the lowest during 2007-08 especially during standard week 4 to 7. The maximum weekly mean temperature was quite high during standard week 15-18 (mid to end April). Rainfall during the crop season was higher in 2006-07 than in 2005-06 and 2007-08.

Treatments and experimental design

Field experiments comprising three/four genotypes (BG 1053, GLK 21143 and GLK 22117 in 2005-06, BG 1053, GLK 22117, GLK 23008 and GLK 23035 in 2006-07 and BG 1053, GLK 24092 and GLK 25132 in 2007-08) and three seed rates (90, 110 and 130 kg ha^{-1}) were conducted in a factorial randomized block design. The genotypes used in the present studies varied in seed size and phenology, as discussed in Results section.

Crop husbandry

Brief crop husbandry details are given in table 2. The pre-sowing irrigations were applied and at optimum moisture the seed bed was prepared by 2-3 cultivations followed by planking. The sowing was done in rows 30 cm apart and at about 5 cm depth with the drill manually. Total rainfall of 54.4, 284.5 and 87.5 mm was received during the crop season in 2005-06, 2006-07 and 2007-08, respectively. Irrigation was applied as per the need of the crop. Weeds were controlled by spraying a pre-emergence herbicide Stomp 30 EC (pendmethalin) @ 2.5 l ha^{-1} with a knap sack sprayer fitted with flood jet nozzle using 500 litres of water ha^{-1}. Afterwards, weeds were removed by hand weeding wherever necessary. Protective spray of Captaf was done in the month of March against *Ascochyta* blight. Two sprays were done with insecticides in March-April every year against gram pod borer (*Heliothis armigera*).

Observations recorded

Data on days to 50% flowering (when at least one open flower was observed on about 50% plants in the plot) and maturity were recorded for all the genotypes. At maturity, data on plant height, primary branches plant^{-1}, secondary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 100-seed weight were recorded. Grain yield and biological yield data were recorded on whole plot basis and then converted to kg ha^{-1}. Harvesting and threshing were done manually. Harvest index was calculated by dividing grain yield by biological yield and then multiplying by 100. Gross returns, net returns and benefit:cost ratio were also worked out.

Statistical analysis

All data except days to 50% flowering and maturity were subjected to analysis of variance in a factorial randomized block design as per the standard procedure. Wherever the 'F' ratio was significant, the critical difference (CD) values were calculated at 5% level of significance.

Results and Discussion

Weather

The weekly minimum and maximum temperatures experienced by the crop and the rainfall received during the crop season are presented in figure 1. At sowing and emergence, the maximum temperature varied between 22°C and 29°C and the minimum temperature was 7°C to 13°C. During the months of December and January, both maximum and minimum temperatures dropped. During these two months the minimum temperature varied between 3.1°C and 10.3°C in 2005-06, 1.8°C and 9.6°C in 2006-07 and 0.9°C and 10.7°C in 2007-08. In the months of March and April, the temperatures raised and the maximum weekly temperature was more than 35°C in some weeks in April.

Performance of genotypes

In 2005-06, GLK 22117 and GLK 21143 were on par in plant height and both were significantly taller than BG 1053 (Table 3). However, BG 1053 had significantly higher number of secondary branches plant^{-1} and pods plant^{-1} than the other two genotypes. Primary branches plant^{-1} and seeds pod^{-1} were similar in all the three genotypes. GLK 22117 had the highest 100-seed weight of 36.0 g whereas GLK 21143 and BG 1053 had 100-seed weight of 34.7 and 32.4 g, respectively. BG 1053 was significantly superior to GLK 22117 and GLK 21143 in grain yield. GLK 21143 was the lowest in grain as well as biological yield.

In 2006-07, GLK 22117 and GLK 23008 registered higher plant height but lower secondary branches plant^{-1} than BG 1053 and GLK 23035 (Table 4). Primary branches plant^{-1} and pods plant^{-1} were not significantly influenced by genotypes. GLK 23035 had lowest seeds pod^{-1} but highest 100-seed weight. GLK 22117 yielded grains significantly higher than GLK 23008 and GLK 23035 but was on par with BG 1053. All genotypes were on par in biological yield.

In 2007-08, GLK 24092 produced tallest plants (Table 5), BG 1053 had highest seeds pod^{-1} and GLK 25132 had highest 100-seed weight. Primary branches plant^{-1}, secondary branches plant^{-1} and pods plant^{-1} were not influenced significantly. GLK 24092 recorded significantly higher grain yield than GLK 25132 but it was on par with BG 1053. Genotypes did not differ in biological yield.

Effect of seed rate

In 2005-06, highest plant height and primary branches plant^{-1} were recorded in case of 130 kg ha^{-1} seed rate (Table 3), highest secondary branches plant^{-1} and pods plant^{-1} with 90 kg ha^{-1} seed rate, and highest 100-seed weight, grain yield and biological yield with 110 kg ha^{-1} seed rate.

In 2006-07, a seed rate of 130 kg ha^{-1} produced tallest plants and highest grain as well as biological yields. Other plant growth and yield attributes were not influenced significantly.

In 2007-08, highest plant height was recorded with a seed rate of 130 kgha^{-1} whereas maximum pods plant^{-1} and grain yield were registered with 110 kgha^{-1} seed rate. Other plant growth, yield attributes and biological yield were not influenced significantly.

Genotypes × Seed rate interaction effect

The genotypes × seed rate interaction was significant with respect to the grain yield in 2005-06 and 2006-07 (Table 6). In 2005-06, highest grain yield was produced by BG 1053 with 110 kg ha^{-1} seed rate (1667 kg ha^{-1}), which was significantly higher than the grain yields produced by other genotypes at all three seed rates. In 2006-07, GLK 22117 with 110 kg ha^{-1} seed rate produced the highest grain yield (1385 kg ha^{-1}), which was, however, on par with grain yields produced by BG 1053 with 90 and 110 kg ha^{-1} seed rate (1244 and 1320 kg ha^{-1}), GLK 22117 with 90 and 130 kg ha^{-1} seed rate (1287 and 1244 kg ha^{-1}) and GLK 23035 with 130 kg ha^{-1} seed rate (1277 kg ha^{-1}). In 2007-08, all three genotypes produced higher grain yields with 110 and 130 kg ha^{-1} than 90 kg ha^{-1} seed rate.

Economics

Genotype BG 1053 in 2005-06, GLK 22117 in 2006-07 and GLK 24092 in 2007-08 provided the highest gross returns (Table 7), net returns (Table 8) and B:C ratio (Table 9). On the basis of three-year mean, a seed rate of 110 kg ha^{-1} provided the highest gross as well as net returns followed by seed rate of 130 kg ha^{-1} whereas B:C ratio was the highest with seed rate of 110 kg ha^{-1} followed by 90 and 130 kg ha^{-1} seed rates.

Phenology

Time taken to 50% flowering and maturity varied with the genotypes and years (Table 10). In general, time taken to 50% flowering was shortest (88-95 days) in 2005-06 whereas time to maturity was shortest in 2007-08 (136-144 days). Time taken to 50% flowering (106-110 days) as well as maturity (156-163 days) was longest in 2006-07.

Chickpea is an important grain legume having protein-rich grains. Two types of chickpeas – *desi* and *kabuli* are grown. *Kabuli* types have higher market price, which provides farmers with higher income. Seed is a basic and costly input in agriculture. Use of optimum seed rate is essential for maintaining adequate plant population and consequently for obtaining higher grain yields. On mean basis, compared with 90 kg ha^{-1} seed rate, seed rates of 110 and 130 kg ha^{-1} produced +10.42% and –1.84% yields in 2005-06, +12.05% and +12.61% in 2006-07 and +52.47% and +46.76% in 2007-08. On the basis of three years average, 24.66% and 18.31% higher grain yields were obtained with 110 and 130 kg ha^{-1} seed rate over 90 kg ha^{-1}. Grain yield in chickpea is influenced greatly with seed rate (Venkatachalapathi and Saini, 2003; Nagarajaiah *et al.,* 2005; Kumar *et al.,* 2008; Kumar *et al.,* 2009).

Plant height was highest with the highest seed rate of 130 kg ha^{-1} in all the three years (Tables 3, 4 and 5), which could be due to competition amongst the plants for sunlight. As the seed rate increased, pods $plant^{-1}$ decreased in 2005-06 (Table 3) and 2006-07 (Table 4) as also reported by other researchers (Khan *et al.,* 1999; Venkatachalapathi *et al.,* 2004; Choudhary *et al.,* 2005), which could be due to competition amongst the plants for nutrients and moisture. The 100-seed weight was not influenced due to seed rates in 2006-07 and 2007-08 (Tables 4 and 5) as generally it is not influenced by environment, as reported by other researchers also (Mansur *et al.,* 2009).

High grain yields obtained with the use of 110 kg ha^{-1} seed rate (Tables 3-5) could be due to reasonably good number of pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight. Though pods $plant^{-1}$ decreased with the increase in seed rate, higher grain yields obtained with 100 and 130 kg ha^{-1} over 90 kg ha^{-1}seed rate (except in 2005-06) could be due to higher number of pods per unit area owing to increased plant populations. Grain yields in chickpea are strongly and positively correlated with the number of pods and seeds m^{-2} (Gan *et al.,* 2003c; Ayaz *et al.,* 2004b). With increased plant population, the green area index, intercepted radiation, radiation use efficiency and total intercepted photosynthetically active radiation increase (Ayaz *et al.,* 2004c), thereby resulting in higher grain yields. Biological yield increased with an increase in seed rate (except in 2005-06), which may be the result of increased plant population. Biological yield is known to increase with increased plant population (Ayaz *et al.,* 2004a). Quite good grain and biological yields with 90 kg ha^{-1} seed rate in 2005-06 may be due to favourable weather conditions (Figure 1) for plant growth.

Seed rates influenced gross returns (Table 7) and net returns (Table 8), which, on the basis of three-year mean, were the highest with a seed rate of 110 kg ha^{-1}, followed by 130 kg ha^{-1} and 90 kg ha^{-1}. The trend in returns with different seed rates was the same as for grain yield. Other researchers also reported variation in returns with different seed rates (Choudhary *et al.,* 2005; Nagarajaiah *et al.,* 2005; Kumar *et al.,* 2009). The B:C ratio was the highest with a seed rate of 110 kg ha^{-1} and, unlike grain yield or gross and net returns, was lower with 130 kg than 90 kg ha^{-1} seed rate as the use of the highest seed rate also involved higher cost and the gain in grain yield was not that much which could compensate the cost involved.

Seed rate influenced harvest index slightly in 2005-06 and 2006-07 but more so in 2007-08. Harvest index was higher in 2007-08 (Table 5) than in 2005-06 (Table 3) and 2006-07 (Table 4). Biological yield was low in 2007-08, which could be due to restricted plant growth during the months of December, January and February owing to very low minimum temperature (Figure 1) and frost occurrence. This checked over vegetation growth and consequently favoured better source-sink relationship. Grain yields were generally lower in 2006-07 than in 2005-06 and 2007-08, which could be due to, apart from different genotypes, variation in temperatures (Figure 1) and rainfall (Table 1). Other researchers have also reported large year-to-year variation in chickpea grain yields (Kibe and Kamithi, 2007).

Among genotypes, BG 1053, GLK 22117, GLK 24092 and GLK 25132 were the high yielders. These genotypes produced higher grain yields due to higher number of pods plant^{-1}, seeds pod^{-1} and/or higher 100-seed weight. Genotypes of chickpea do differ in productivity (Sekhon *et al.*, 2001; Nagarajaiah *et al.*, 2005; Bavalgave *et al.*, 2009; Aggarwal *et al.*, 2016). Maturity duration differed with genotype and year (Table 10). In northern India, chickpea experiences sudden rise in temperature near maturity, which adversely affects grain development and consequently grain yield. Therefore, genotypes with shorter duration may help in avoiding high temperature induced reduction in the yield.

Table.1 Total monthly rainfall received during the crop growing season in 2005-06, 2006-07 and 2007-08

Month	Rainfall received (mm)		
	2005-06	2006-07	2007-08
November	0.0	14.0	1.3
December	0.0	22.7	17.7
January	16.8	10.0	16.3
February	0.0	85.6	2.0
March	32.5	126.0	0.0
April	5.1	26.2	50.2
Total	54.4	284.5	87.5

Table.2 Treatments and crop husbandry details of three years of the study

Particulars	2005-06	2006-07	2007-08
Genotypes	BG 1053, GLK 21143 and GLK 22117	BG 1053, GLK 22117, GLK 23008 and GLK 23035	BG 1053, GLK 24092 and GLK 25132
Seed rates (kg ha^{-1})	90, 110 and 130	90, 110 and 130	90, 110 and 130
Design	Factorial RBD	Factorial RBD	Factorial RBD
Replications	4	4	3
Date of sowing	11 November 2005	11 November 2006	14 November 2007
Date of harvesting	29 April 2006	25 April 2007	28 April 2008

Table.3 Effect of genotypes and seed rate on plant traits and grain yield of kabuli chickpea in 2005-06

Treatment	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Genotype									
BG 1053	39.6	4.43	10.40	30.1	1.28	32.4	1529	4320	35.39
GLK 21143	44.9	4.47	8.30	24.0	1.28	34.7	1227	3803	32.26
GLK 22117	46.3	4.23	9.80	22.8	1.23	36.0	1419	4355	32.58
CD 5%	1.8	NS	0.50	2.1	NS	0.8	85	258	
Seed rate (kg ha^{-1})									
90	42.1	4.03	10.40	27.7	1.32	33.6	1353	4196	32.24
110	43.3	4.38	8.80	26.7	1.24	35.2	1494	4334	34.47
130	45.4	4.72	9.30	22.5	1.23	34.4	1328	3948	33.63
CD 5%	1.8	0.20	0.50	2.1	NS	0.8	85	258	

Table.4 Effect of genotypes and seed rate on plant traits and grain yield of kabuli chickpea in 2006-07

Treatment	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Genotype									
BG 1053	50.9	1.96	5.43	25.2	1.40	29.8	1241	4329	28.66
GLK 22117	56.5	1.98	5.00	23.6	1.36	32.2	1306	4581	28.50
GLK 23008	55.7	1.96	5.05	24.7	1.31	33.0	997	4264	23.38
GLK 23035	52.7	2.10	5.31	23.0	1.20	36.4	1053	4242	24.82
CD 5%	2.3	NS	0.34	NS	0.11	0.4	90	NS	
Seed rate (kg ha^{-1})									
90	50.6	1.97	5.32	24.7	1.31	32.8	1062	4036	26.31
110	54.6	2.03	5.21	24.6	1.31	32.8	1190	4426	26.88
130	56.7	2.00	5.06	23.2	1.32	32.9	1196	4599	26.00
CD 5%	2.0	NS	NS	NS	NS	NS	78	256	

Table.5 Effect of genotypes and seed rate on plant traits and grain yield of kabuli chickpea in 2007-08

Treatment	Plant height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	100-seed weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Genotype									
BG 1053	44.8	4.09	6.84	26.1	1.64	28.2	1549	4156	37.27
GLK 24092	52.3	3.87	5.89	24.0	1.38	33.9	1692	3981	42.50
GLK 25132	45.5	4.13	6.92	21.6	1.51	36.8	1446	3539	40.85
CD 5%	2.0	NS	NS	NS	0.17	0.4	169	NS	
Seed rate (kg ha^{-1})									
90	45.8	3.82	7.04	21.6	1.53	33.0	1174	3426	34.26
110	47.8	4.04	6.42	27.6	1.53	33.0	1790	4064	44.04
130	49.0	4.22	6.19	22.5	1.47	33.0	1723	4187	41.15
CD 5%	2.0	NS	NS	4.1	NS	NS	169	NS	

Table.6 Grain yield of kabuli chickpea genotypes as influenced by seed rates

Year	Genotype	Grain yield (kg ha^{-1}) Seed rate (kg ha^{-1})			Mean
		90	110	130	
2005-06	BG 1053	1439	1667	1480	1529
	GLK 21143	1118	1375	1190	1227
	GLK 22117	1501	1441	1315	1419
	Mean	1353	1494	1328	
2006-07	BG 1053	1244	1320	1158	1241
	GLK 22117	1287	1385	1244	1306
	GLK 23008	925	963	1104	997
	GLK 23035	790	1093	1277	1053
	Mean	1062	1190	1196	
2007-08	BG 1053	1160	1790	1697	1549
	GLK 24092	1250	1960	1867	1692
	GLK 25132	1111	1621	1605	1446
	Mean	1174	1790	1723	
	Overall mean	1196	1491	1415	

CD 5%	2005-06	2006-07	2007-08
Genotypes (G)	85	90	169
Seed rates (S)	85	78	169
G × S interaction	148	157	NS

Table.7 Gross returns of kabuli chickpea genotypes as influenced by seed rates

Year	Genotype	Gross returns (Rs ha^{-1}) Seed rate (kg ha^{-1})			Mean
		90	110	130	
2005-06	BG 1053	71950	83350	74000	76433
	GLK 21143	55900	68750	59500	61383
	GLK 22117	75050	72050	65750	70950
	Mean	67650	74700	66400	
2006-07	BG 1053	62200	66000	57900	62033
	GLK 22117	64350	69250	62200	65267
	GLK 23008	46250	48150	55200	49867
	GLK 23035	39500	54650	63850	52667
	Mean	53100	59500	59800	
2007-08	BG 1053	58000	89500	84850	77450
	GLK 24092	62500	98000	93350	84617
	GLK 25132	55550	81050	80250	72283
	Mean	58700	89500	86150	
	Overall mean	59800	74550	70750	

Table.8 Net returns of kabuli chickpea genotypes as influenced by seed rates

Year	Genotype	Net returns (Rs ha^{-1})			Mean
		Seed rate (kg ha^{-1})			
		90	110	130	
2005-06	BG 1053	56750	66550	55600	59633
	GLK 21143	40700	51950	41100	44583
	GLK 22117	59850	55250	47350	54150
	Mean	52450	57900	48000	
2006-07	BG 1053	47000	49200	39500	45233
	GLK 22117	49150	52450	43800	48467
	GLK 23008	31050	31350	36800	33067
	GLK 23035	24300	37850	45450	35867
	Mean	37900	42700	41400	
2007-08	BG 1053	42800	72700	66450	60650
	GLK 24092	47300	81200	74950	67817
	GLK 25132	40350	64250	61850	55483
	Mean	43500	72700	67750	
	Overall mean	44600	57750	52350	

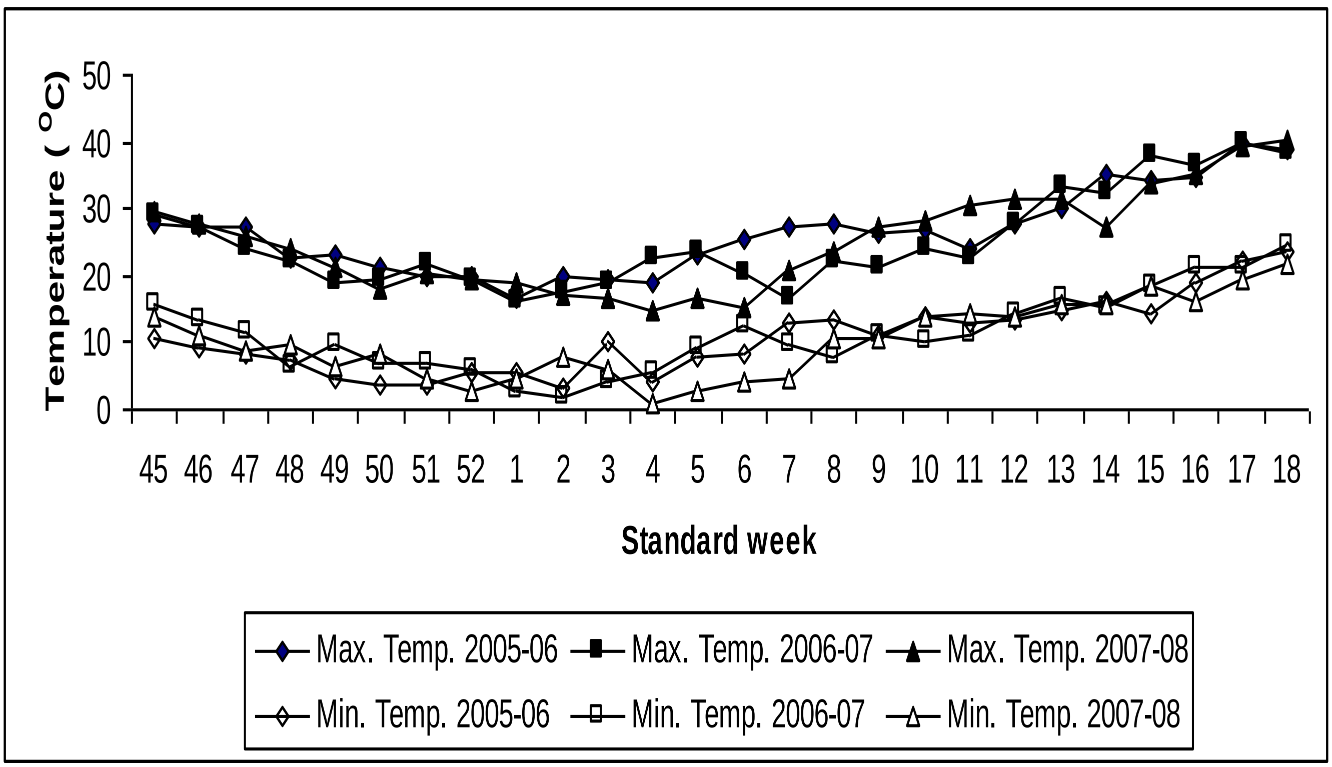
Table.9 Benefit:cost ratio of kabuli chickpea genotypes as influenced by seed rates

Year	Genotype	B:C ratio			Mean
		Seed rate (kg ha^{-1})			
		90	110	130	
2005-06	BG 1053	4.73	4.96	4.02	4.57
	GLK 21143	3.68	4.09	3.23	3.67
	GLK 22117	4.94	4.29	3.57	4.27
	Mean	4.45	4.45	3.61	
2006-07	BG 1053	4.09	3.93	3.15	3.72
	GLK 22117	4.23	4.12	3.38	3.91
	GLK 23008	3.04	2.87	3.00	2.97
	GLK 23035	2.60	3.25	3.47	3.11
	Mean	3.49	3.54	3.25	
2007-08	BG 1053	3.82	5.33	4.61	4.59
	GLK 24092	4.11	5.83	5.07	5.00
	GLK 25132	3.65	4.82	4.36	4.28
	Mean	3.86	5.33	4.68	
	Overall mean	3.93	4.44	3.85	

Table.10 Days taken to 50% flowering and maturity by different genotypes of kabuli chickpea

Year	Genotype	Days taken to	
		50% flowering	Maturity
2005-06	BG 1053	88	146
	GLK 21143	95	152
	GLK 22117	90	148
2006-07	BG 1053	108	163
	GLK 22117	106	156
	GLK 23008	110	161
	GLK 23035	109	158
2007-08	BG 1053	100	139
	GLK 24092	103	144
	GLK 25132	98	136

Fig.1 Weekly mean minimum and maximum temperatures recorded at the Meteorological Observatory of the Punjab Agricultural University, Ludhiana, India



In chickpea, Ascochyta blight, Botrytis grey mould and Fusarium wilt are the serious diseases. In the present studies, no occurrence of any of these diseases was observed. This could be due to resistance in the tested genotypes against all these diseases or the occurrence of Ascochyta blight was avoided due to the protective spray with a fungicide Captaf. Chickpea genotypes do vary in resistance to Ascochyta blight (Gan *et al.*, 2003a).

In *kabuli* chickpea, in a breeding programme, generally the main objective is not only to develop high yielding disease resistance genotypes but also those genotypes which have bold seeds, as bold seeded chickpeas fetch higher market price. However, bold-seeded genotypes may not always give higher grain yields, because the genotypes having higher 100-seed weight generally have lower number of pods plant^{-1} or seeds pod^{-1} (Liu *et al.*, 2003; Singh and Sekhon 2006; Sheoran *et al.*, 2008) as also observed in the present study (Tables 3-5). Kumar *et al.*, (2008) also reported higher grain yield of genotype BG 1053 with 100 kg ha^{-1} seed rate than with 75 or 125 kg ha^{-1}.

In conclusion, in northern Indian states, especially Punjab, Haryana and western Uttar Pradesh, underground water is going deep at an alarming rate. There is a need to shift from high water requiring cropping system of rice-wheat to some other low water requiring crops such as chickpea during winter season. *Kabuli* chickpea, due to its high market price, can economically compete well with wheat. For obtaining high yield as well as net returns a seed rate of 110 kg ha^{-1} should be used. BG 1053, GLK 22117, GLK 24092 and GLK 25132 are promising genotypes.

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