Response of chickpea (*Cicer arietinum*L).Genotypes to rhizobial inoculation and fertilizer application

Running Title: Genotype by environment interaction in chickpea

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Novelty statement:

1) Rhizobium inoculation is proved to increase chickpea yield on significantly higher rate than nitrogen application.
2) Response of all chickpea genotypes was expressively positive to rhizobium inoculation as compare to nitrogen application

ABSTRACT

World's pollution increased due to excessive and inappropriate application of mineral fertilizer's. Chickpea is an important sourceof protein, as well as an excellent source of biological nitrogen fixation.Fifteen chickpea genotypes were evaluated under rhizobial inoculation, nitrogen application and controlled environments at The University of Agriculture Peshawar during 2016-17. Genotypes were planted in randomized complete block design with three replications under each environment. Data were recorded on morphological and yield traitscmbined analysis of variance revealed significant differences among environments, genotypes and G × E interaction for all the studied traits. Mean values of genotypes over environments for days to maturity ranged from 171.5 (SL-3-29) to 189.7 (NDC-15-1), plant height from 43.9 (SL-3-29) to 56.1 cm (NDC-122), pods plant^{-1} from 30.9 (NDC-4-20-1) to 58.2 (Karak-1), 100 seed weight from 14.9 (SL-3-29) to 25.8 g (Karak-1) and seed yield plant^{-1} from 11.4 (SL-3-29) to 23.2 g (Karak-1). Genotype × environment interaction for seed yield plant^{-1} ranged from 10.3 (SL-3-29) to 27.6 g (Karak-1). Among environments maximum seed yield plant^{-1}(27.6 g) was recorded under inoculated environment while minimum seed yield plant^{-1}(19.6 g) under controlled environment. The impact of seed inoculation was more on yield ascompared to fertilized and controlled environments. Hence bacterial inoculation is proved to be an economic and environment friendly source of chickpea yield improvement. Genotypes Karak-1, NIFA-2005 and Karak-3 out yielded all other genotypes under all the studied environments and could be suggested for general cultivation and utilization in future breeding strategies

Key Words: Chickpea; fertilizer application; inoculation; interaction; rhizobium

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a diploid (2n=2x=16) self-pollinated annual specie belonging to family Fabaceae. It is mainly grown in the rainfed areas of Pakistan and is the most important pulse crop of our country.Kabuli and Desi are the two major types of chickpea. Kabuli type has cream color seed, white flower and is grown in the temperate regions while the Desitype has brown color seed, pink flower and is mostly grown in the semi-arid tropics (Muehlbauer and Singh, 1987). For low yield of chickpea the major constraints are genotypes with lower yield potential, sensitivity to excess ofwater, fertilizer, biotic and abiotic factors(excess soil moisture and rainfall)etc. (Ali *et al*., 2008).For obtaining higher grain yield in chickpea it is necessory to follow proper agronomic practices and applying specific nutrients.Although Chickpea is a leguminous crop andit can fix atmosphericnitrogen with the help of rhizobia, for proper growth and development of the planta starter dose of nitrogen is essential. With the application of nitrogen as a starter dosechickpea grain yield could be enhanced(Namvar *et al*. 2011).

Chickpea is predominantly consumed as a pulse both in green and dried form. Its grains are eaten roasted and boiled as snack food, parched, fried, fresh as green vegetables, sweet and condiments; Its flour can be used to make bread, as soup and dal. Young plants of chickpea specially its green pods are used as green vegetables. It is the cheapest and readily available source of protein (19.5%), carbohydrates (57-60%), fats (11.4%), moisture (4.9-15.59%) and ash (4.8%) (Huisman and Poel, 1994). Due to its nitrogen fixation ability, apart from getting dietary benefits people also use chickpea in crop rotation and in the management of soil fertility (Kantar *et al*., 2007).

For proper growth and development chickpea needs about 13 to 41 kg ofnitrogen ha^{-1} for. Chickpea yield could be improved at low cost by using nitrogen fixing *Rhizobium* bacteria (Kucuk and Kıvanc, 2008). As it fixes atmospheric nitrogen through symbiosis with nitrogen fixing bacteria (*Rhizobium Cicer*), thereforenitrogen applications are generally not necessary (Rhinhart *et al*. 2003). The average yield of chickpea is very low than its potential yield. The absence of effective rhizobial inoculation,unavailability of good quality seed, and severe damage by pod borer attack and blight were observed to be responsible for truncated yields. For the improvement of root nodulation and yield of the crop,It is a very useful practice toinoculate chickpea seedsappropriate rhizobia, in those soils which are deficient in native effective rhizobia (Shah *et al*., 1994). Even in those soils that contain its native rhizobia,chickpea gives positive response to rhizobial inoculation (Sharma *et al*., 1983). In Pakistanmost of our soils are deficient in nitrogen; Its deficiency usually results in low crop yield, because nitrogen is the most vital element plant metabolism and protein synthesis. In most legumes for the stimulation of early growth and to induce nitrogen fixation by bacteria a starter dose of fertilizer nitrogen is often used (Ali *et al*., 1998).

Synthetic fertilizer is playing a vigorous role in therising problem of air and soil pollution.So, there is a great need that farmers should use organic fertilizers and biological nitrogen fixationfor the improvement of soil fertility. In this regard legumes can play a great role and especially when we inoculate seed or soil with rhizobia (bacteria) the rate of biological nitrogen fixation boosts and crop yield improves tremendously. So, keeping in view above mentioned facts the present study was planned to evaluate the response of chickpea genotypes comparatively to fertilizer application and rhizobial inoculation; assess their effect on development, yield and yield related traits of chickpea; investigate the interaction of genotype with fertilizer and rhizobia, andto identify suitable genotypes and environments with respect to growth and yield performance of chickpea genotypes.

MATERIALS AND METHODS

Theresearch wasperformed at the malakander farm of The University of Agriculture, Peshawar, during 2019-20. Fifteen chickpea genotypes were assessed in this study (Table 1). These genotypes were evaluated under three different environments i.e. rhizobium inoculation (Thal-8), nitrogen application (@25 kg ha^{-1}) andControl. Randomized complete block design with three replications was used to perform the experimen.Each plot was consisted of four rows (4 m), 10 cmplant-to-plant distance and 30 cm row-to-row distance while plot-plot distance was 60 cm. Insecticide(Emamectin) was sprayed to control pod borers at the time of pod formation.

Inoculant preparation and use

For inoculation a slurry was made by mixing 40g of inoculants in 300 ml of 5% sugar solution. With the helpof sugar solution the adhesion of inoculantenhanced to the seed. Than the slurry was poured on the seed in a clean container and mixed thoroughly, untilinoculant coated all the seeds uniformly. Sunlight effects the bacteria Therefore the whole inoculation procedure was carried out in shade. After inoculation seed was sown directly.

Statistical analysis

Software Statistix 8.1 was used for data analysis.Amongthe performance of genotypes for various charactersthat showed significant variations, their means were further separated and compared by using the least significant difference (LSD) test at 5% probability level.

Table 1. Chickpea genotypes with parentage and origin.

S.No	Genotypes	Groups	Parentage	Origin
1	NDC-4-20-5	Desi	C-44/M	NIFA, Pakistan
2	NDC-4-20-4	Desi	C-44/M	NIFA, Pakistan
3	SL-3-15	Desi	Local selection	Karak, Pakistan
4	NDC-4-20-1	Desi	C-44/M	NIFA, Pakistan
5	NDC-15-1	Desi	Pb-91/M	NIFA, Pakistan
6	NDC-122	Desi	C-44×ILC-195	NIFA, Pakistan
7	SL-8-14	Desi	Local selection	Karak, Pakistan
8	NIFA-2005	Desi	Pb-91/M	NIFA,Pakistan
9	KARAK-1	Desi	Local selection	Karak, Pakistan
10	NDC-4-20-6	Desi	C-44/M	NIFA, Pakistan
11	NDC-4-20-2	Desi	C-44/M	NIFA, Pakistan
12	SL-03-29	Desi	Local selection	Karak, Pakistan
13	SL-3-64	Desi	Local selection	Karak, Pakistan
14	KARAK-3	Desi	Local selection	Karak, Pakistan
15	NDC-4-20-3	Desi	C-44/M	NIFA, Pakistan

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among genotypes, genotype by environment interactions and among environments (controlled, inoculated, fertilized) for days to maturity, plant height, pods plant^{-1}, seeds plant^{-1}, 100 seed weight and seed yield plant^{-1}.This shows that the performance of genotypes across the environments was not consistent (Table 2). Furthermore, interactions of inoculated environment with controlled as well as with fertilizer application also differed significantlyfor most of the studied traits among (Table 2). Mahmud *et* *al.* (2007) also reported significant differences among genotypes, environments and G × E interaction effects for yield and yield associated traits of chickpea.

Mean values for days to maturity of the studied genotypes ranged from 174.3 to 193.0, 169.3 to 186.6 and 171.0 to 189.6 days with the mean value of 183.9, 180.5 and 181.9 days under controlled, inoculated and fertilized environments, respectively (Table 3 &Fig. 1). Interaction of genotypes with environments ranged from 169.3 to 193.0 days (Table 3). Chickpea genotypes generally took less days to maturity under inoculated than fertilized and controlled environments. Maximum days to maturity were observed for genotype NDC-15-1 (186.6), followed by NIFA-2005 and Karak-3 (184.6 days) under inoculated condition, while the same genotype NDC-15-1 took more days to maturity i.e. 193.0 and 189.6 days under controlled and fertilizedenvironments respectively. In contrast, minimum days to maturity were recorded for SL-3-29 measuring 169.3, 174.3 and 171.0 days with the mean value of 171.5 days under inoculated, controlled and fertilized environments. In genotypes mean over three production environments, earliest maturity was recorded for genotype SL-3-29 (171.5 days), whereas maximum days to maturity were taken by genotype NDC-15-1 (189.7 days). Early maturity may be due to more nodulation, growth and nitrogen uptake in chickpea genotypes resulting primal growth. Namvar *et al.* (2011) also observed that Rhizobium inoculation significantlyaffecting the growth period of chickpea. Delay in maturity might be due to genetic makeup of the genotypes and its interaction with that specific environment. Plant breeder's major aim is to develop early maturing genotypes, which give high yields in less period of time.

Mean values for plant height ofgenotypes ranged from 46.3 to 59.6, 43.3 to 57.6 and 42.3 to 52.0 cm with the mean value of 54.2, 51.4and 47.6cm under inoculated, fertilized and controlled environment, respectively (Table 3 &Fig. 2). The interaction between genotype and environment the mean value ranged from 42.3 to 59.6cm. Chickpea genotypes generally produced tallest plants under inoculated condition as compared with controlled and fertilized environments.Table 3 shows that the tallest plants were observed in genotype NDC-122 measuring 59.6, 57.6 and 52.0 cm under inoculated, fertilized and controlled environment, respectively. On the other hand, genotype SL-3-29 produced shortest plants measuring 46.3, 43.3 and 42.3 cm under inoculated, fertilized and controlled environment, respectively. In averaged mean for genotype over three environments, minimum and maximum values for plant height were recorded for genotype SL-3-29 (43.9 cm) and NDC-122 (56.1 cm), respectively. The study revealed that genotype NDC-122 (59.6cm) showed taller plants by Rhizobium inoculation as compared to genotype SL-3-29 (43.3, 42.3cm) which showed smaller plants under inoculated and fertilized environments, respectively.This might be due to the fact that Rhizobium inoculation provided better soil environment for nutrients uptake indicated taller plants. Sharar *et al.* (2000) also reported that inoculated seeds produced significantly taller plant as compared with uninoculated seeds. Karasu *et al.*(2009) who reported that Rhizobium inoculation of chickpea seeds showed a significant effect on plant height In taller plants lodging occurs, which ultimately affect yield as compared with short stature genotypes. Therefore, short stature genotypes are desirable to decrease lodging in crop plants (Yucel *et al.,* 2006).

Mean values for pods plant^{-1}of genotypes ranged from 33.3 to 63.3, 32.3 to 62.9 and 27.3 to 49.0 with the mean value of 48.3, 46.3 and 37.8 pods under inoculated, fertilized and controlled environments, respectively (Table 4 &Fig. 3). The interaction of genotypes with environments the mean value ranged from 27.3 to 63.3 pods. The studied genotypes produced more pods plant^{-1} in inoculated condition as compared with other environments. Maximum pods plant^{-1}was produced by genotype Karak-1 i.e. 63.3, 62.9 and 49.0 under inoculated, fertilized and controlled environments, respectively. On the other hand, minimum pods plant^{-1} was recorded for genotype NDC-4-20-1 i.e. 33.3, 32.3 and 27.3 under inoculated, fertilized and controlled production system, respectively. In averaged mean for genotypesover three environments, maximum and minimum pods plant^{-1}was recorded for genotype Karak-1 (58.2) and NDC-4-20-1 (30.9), respectively (Table 4). The observations showed that inoculated genotype Karak-1 produced maximum pods plant^{-1} as compared to genotype NDC-4-20-1 which produced minimum pods plant^{-1} under fertilized and controlled environments, respectively. Our findings were also in agreement with the results of Namvar *et al.* (2011) andAmany (2007)regarding pods plant^{-1}.

Mean values for seeds plant^{-1} of the studied genotypes ranged from 33.0 to 88, 32.0 to 84 and 29.0 to 78.3 with the men value of 62.1, 59.1 and 56.1 seeds plant^{-1} under inoculated, fertilized and controlled environments, respectively (Table 4 &Fig. 4). The mean value of genotypes with environments ranged from 29 to 88 seeds plant^{-1}.Overall, the genotypes produced more number of seeds plant^{-1} under inoculated environment as compared with fertilized and controlled environments. Maximum seeds pant^{-1}was recorded for genotype Karak-1 i.e. 88.0, 84.0 and 78.3, followed by NIFA-2005 i.e. 79.6, 77.3 and 74.0 under inoculated, fertilized and controlled environments respectively. On the other hand, minimum seeds plant^{-1}was observed for genotype NDC-4-20-1 (33.0, 32.0 and 29.0) under inoculated, fertilized and controlled production systems, respectively. Inaveraged mean of genotypes over the contrasting environments, minimum and maximum seeds plant^{-1} were recorded for genotype NDC-4-20-1 (31.3 seeds) and Karak-1 (83.4 seeds), respectively (Table 4). The increase in seeds plant^{-1} under inoculated condition may be due to better nutrient availability and its uptake by plant. Amany (2007) also reported significant effects of nitrogen fertilization for number of seeds plant^{-1} as compared to controlled condition. while Togay *et al.* (2008) reported significant effects of Rhizobium inoculation for seed plant^{-1}. Karasu *et al.* (2009) reported that seeds plant^{-1} was significantly affected by rhizobium inoculation while nitrogen application had no significant effect.

Mean values for 100 seed weight of genotypes ranged from 18.6 to 28.3g, 13.6 to 25.0g and 12.6 to 24.3g, with the mean value 22.9, 21.2 and 18.0g under inoculated, fertilized and controlled environments, respectively (Table 5 &Fig. 5). Genotype over environment interaction mean ranged from 12.6 to 28.3g.Maximum value of 100 seed weight was recorded for genotype Karak-1 measuring 28.3, 25.0 and 24.3g, followed by Karak-3 i.e. 26.0, 25.3 and 19.3g under inoculated, fertilized and controlled environments, respectively. On the other hand, minimum 100 seed weight was recorded for genotype SL-3-29 measuring 18.6, 13.6 and 12.6g under inoculated, fertilized and controlled environments respectively. Mean over the different environments, minimum and maximum 100 seeds weight were recorded for genotype SL-3-29 (14.9g) and Karak-1 (25.8g), respectively (Table 5).The observation showed that genotype Karak-1 gave maximum 100 seed weight under Rhizobium inoculation as compared to genotype SL-3-29 which showed minimum 100 seed weight under fertilized and controlled environments, respectively. Karasu *et al.* (2009) reported highly significant differences among genotypes for 100 seed weight. Zaman *et al.*(2011) also reported that inoculation with Rhizobium increased 50% seed weight.

Mean values for seed yield plant^{-1} of 15 chickpea genotypes evaluated under inoculated, fertilized and controlled environments are given in Table 5. Seed yield plant^{-1}of the studied genotypes ranged from 12.6 to 27.6, 11.3 to 22.6 and 10.3 to 19.6 g with the mean value of18.0, 15.4 and 13.9 g under inoculated, fertilized and controlled environments, respectively (Fig. 6). The interaction of genotypes with environments mean value ranged from 10.3 to 27.6g.The genotypes produced maximum seed yield plant^{-1} under inoculated condition as compared with fertilized and controlled environments respectively. Maximum seed yield plant^{-1} was recorded for genotype Karak-1 i.e. 27.6, 22.6 and 19.6 g under inoculated, fertilized and controlled production system, respectively (Table 5). On the other hand, minimum seed yield plant^{-1} was recorded for genotype SL-3-29 i.e. 12.6, 11.3 and 10.3 g under inoculated, fertilized and controlled conditions, respectively. In averaged mean of genotypes over environments minimum seed yield was recorded for genotype SL-3-29 (11.4g) while maximum for genotype Karak-1 (22.6g).The observations revealed that inoculated genotypes give high seed yield plant^{-1} as compared to fertilized and controlled environments, respectively. This might be due to availability of good soil condition by inoculation for root expansion and efficient uptake of nutrients for growth and development. Tellawi *et al*. (2007), Akhtar *et al.* (2013) and Gul *et al.* (2014), , also reported a significant differences among chickpea genotypes for seed yield plant^{-1}.Khanam *et al.* (1994), Bhuiyan *et al.* (1998), Khattak *et al*. (2006)and Bhuiyan *et al.* (2008)reported that Rhizobium inoculation significantly increased seed yield plant^{-1} as compared with non-inoculated. Gupta and Namdeo (1996) also reported that inoculation of seed with Rhizobium significantly increased seed yield by 9.6 to 27.9%.

Conclusion:

Genotypes, G X E interaction and environments revealed highly significant differences, for yield and yield related traits, showing great amount of variability among the studied germplasm and altered performance of genotypes over the environments.Genotypes obtained highest mean values for yield and yield components under inoculated environment as compared to fertilized and control environments. This revealed that rhizobial inoculation is the cheapest and effective way to improve chickpea yield and soil fertility. Karak-1, NIFA-2005, and Karak-3 performed better across environments and could be recommended further for general cultivation and breeding programs. There is a great need of farmers awareness sessions and proper marketing of rhizobium inoculum to improve chickpea yield and farmers income as well.

Table 2. Analysis of variance for days to maturity, plant height, pods plant^{-1}, seeds plant^{-1}, 100 seed weight and seed yield plant^{-1}

Source	**Df**	**Days to Maturity**	**Plant Height**	**Pods Plant^{-1}**	**Seeds Plant^{-1}**	**100 seeds weight**	**Seed yield plant^{-1}**
Replications	6	4.21	0.77	3.19	3.35	1.34	2.63
Environments	2	136.65**	483.46**	1393.61**	402.01**	271.6**	192.71**
Genotypes (G)	14	197.18**	89.86**	639.17**	1995.94**	64.93**	93.55**
Genotype × Environment	28	8.94**	16.97**	11.03**	4.22**	3.16**	3.59**
Control vs Inoculated	14	14.28**	29.99**	12.04**	6.37**	2.59^{NS}	5.84**
Controle vs Fertilized	14	2.66^{NS}	16.02**	18.73**	3.46*	3.75**	0.87^{NS}
Inoculated vs Fertilized	14	9.89**	4.90**	2.30^{NS}	3.46*	3.13^{NS}	4.05**
Error	88	0.62	0.40	0.48	0.45	0.42	0.43
CV (%)	----	1.04	2.38	3.27	2.31	6.14	8.31

Table 3. Means for days to maturity and plant height of 15 chickpea genotypesevaluated under control, inoculated and fertilized condition during 2016-017.

	Days to maturity				Plant height			
Genotypes	**Control**	**Inoculated**	**Fertilized**	**GM**	**Control**	**Inoculated**	**Fertilized**	**GM**
NDC-4-20-5	182.3	179.3	181.6	181.0	46.0	55.0	50.0	50.3
NDC-4-20-4	182.6	177.3	178.3	179.4	43.6	59.0	51.3	51.3
SL-3-15	186.3	180.0	184.6	183.6	47.0	52.649.0		49.5
NDC-4-20-1	178.6	175.3	177.0	176.9	47.6	55.0	52.6	51.7
NDC-15-1	193.0	186.6	189.6	189.7	43.0	56.3	52.3	50.5
NDC-122	179.0	174.6	177.3	176.9	51.659.6	57.6		56.2
SL-8-14	188.3	183.6	186.6	186.1	49.3	51.3	49.6	50.0
NIFA-2005	178.6	184.6	178.0	180.4	51.6	54.3	53.6	53.1
KARAK-1	186.3	184.3	185.0	185.2	48.0	51.6	49.6	49.7
NDC-4-20-6	187.3	183.0	186.3	185.5	52.0	55.0	53.6	
NDC-4-20-2	186.6	184.0	185.3	185.3	46.3	59.3	56.6	53.5
SL-3-29	174.3	169.3	171.0	171.5	42.3	46.3	43.3	54.0
SL-3-64	186.3	183.6	185.3	185.0	45.3	46.6	46.0	43.9
KARAK-3	186.0	184.6	184.0	184.8	50.3	53.0	51.0	45.9
NDC-4-20-3	183.6	177.0	178.6	179.7	50.6	57.6	54.3	51.4
								54.1
Env. Mean	**183.9**	**180.5**	**181.9**	**-----**	**47.6**	**54.251.4**		**-----**
LSD for Env.				0.78				0.50
LSD for Geno. across Env.				1.76				1.13
LSD for Geno. × Env.				3.05				1.96

Table 4. Means for pods plant^{-1} and seeds plant^{-1} of 15 chickpea genotypes evaluated under control, inoculated and fertilized condition during 2016-017.

	Pods plant^{-1}				Seeds plant^{-1}			
Genotypes	**Control**	**Inoculated**	**Fertilized**	**GM**	**Control**	**Inoculated**	**Fertilized**	**GM**
NDC-4-20-5	33.0	39.0	36.0	36.0	74.3	79.0	76.6	76.6
NDC-4-20-4	35.3	42.6	40.0	39.3	46.3	51.3	47.0	48.2
SL-3-15	41.3	53.0	49.6	47.9	50.3	54.0	51.3	51.8
NDC-4-20-1	27.3	33.3	32.3	30.9	29.0	33.0	32.0	31.3
NDC-15-1	30.3	39.0	36.6	35.3	57.0	64.6	61.3	60.9
NDC-122	36.0	45.3	40.6	40.6	34.0	36.3	34.6	34.9
SL-8-14	36.3	46.3	43.6	42.0	48.3	53.3	50.3	50.6
NIFA-2005	43.6	55.3	54.3	51.0	74.0	79.6	77.3	76.9
KARAK-1	49.0	63.3	62.9	58.2	78.3	88.0	84.0	83.4
NDC-4-20-6	45.6	59.0	57.0	53.8	67.6	74.6	71.6	71.2
NDC-4-20-2	32.3	44.0	43.3	39.8	60.0	66.6	64.0	63.5
SL-3-29	30.0	40.6	40.0	36.8	50.0	56.3	53.6	53.3
SL-3-64	47.6	63.0	62.8	57.8	57.0	62.0	59.6	59.5
KARAK-3	38.3	47.0	45.0	43.4	56.3	65.6	58.6	60.1
NDC-4-20-3	41.3	53.6	51.3	48.7	59.3	67.0	64.3	63.5
Env. Mean	**37.8**	**48.3**	**46.3**	----	**56.1**	**62.1**	**59.1**	----
LSD for Env.				0.60				0.57
LSD for Geno. across Env.				1.35				1.27
LSD for Geno. × Env.				2.34				2.21

Table 5 . Means for 100 seeds weight and seed yield plant^{-1} of 15 chickpea genotypes evaluated under control, inoculated and fertilized condition during 2016-17.

	100 seed weight				Seed yield plant^{-1}			
Genotypes	**Control**	**Inoculated**	**Fertilized**	**GM**	**Control**	**Inoculated**	**Fertilized**	**GM**
NDC-4-20-5	17.0	20.3	19.0	18.7	16.0	19.3	17.3	17.5
NDC-4-20-4	15.6	21.6	20.3	19.1	16.0	19.6	17.6	17.7
SL-3-15	19.6	27.3	24.0	23.6	14.6	17.0	15.6	15.7
NDC-4-20-1	17.6	23.0	22.0	20.8	10.6	13.6	12.0	12.0
NDC-15-1	19.0	22.0	21.3	20.7	14.0	18.0	16.0	16.0
NDC-122	17.3	22.3	18.6	19.4	11.0	14.0	12.0	12.3
SL-8-14	20.6	25.0	23.3	22.9	14.6	18.3	16.3	16.4
NIFA-2005	17.6	22.3	21.3	20.4	12.6	21.0	13.6	15.7
KARAK-1	24.3	28.3	25.0	25.8	19.6	27.6	22.6	23.2
NDC-4-20-6	19.6	24.0	24.0	22.5	15.3	17.3	16.3	16.3
NDC-4-20-2	17.6	21.6	21.3	20.1	12.3	15.6	13.3	13.7
SL-3-29	12.6	18.6	13.6	14.9	10.3	12.6	11.3	11.4
SL-3-64	16.6	20.0	18.3	18.3	11.3	15.3	12.0	12.8
KARAK-3	19.3	26.0	25.3	23.5	17.3	24.0	20.6	20.6
NDC-4-20-3	16.0	21.0	20.3	19.1	13.6	17.3	15.0	15.3
Env. Mean	**18.0**	**22.9**	**21.2**	----				----
LSD for Env.				0.53				0.55
LSD for Geno. across Env.				1.19				1.23
LSD for Geno. × Env.				2.06				2.13

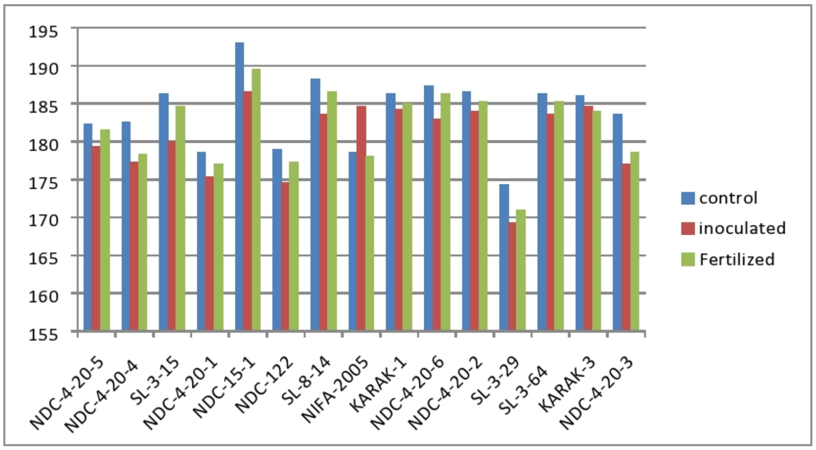

Fig. 1: Days to maturity of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer application

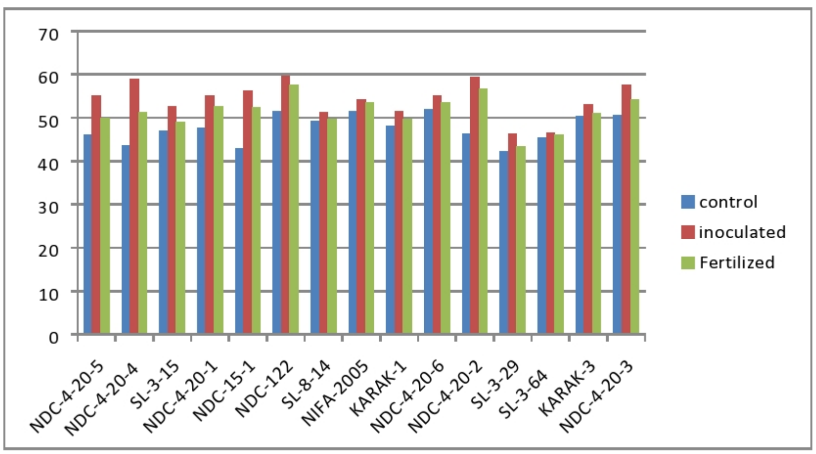

Fig. 2: Plant height of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer applicatio

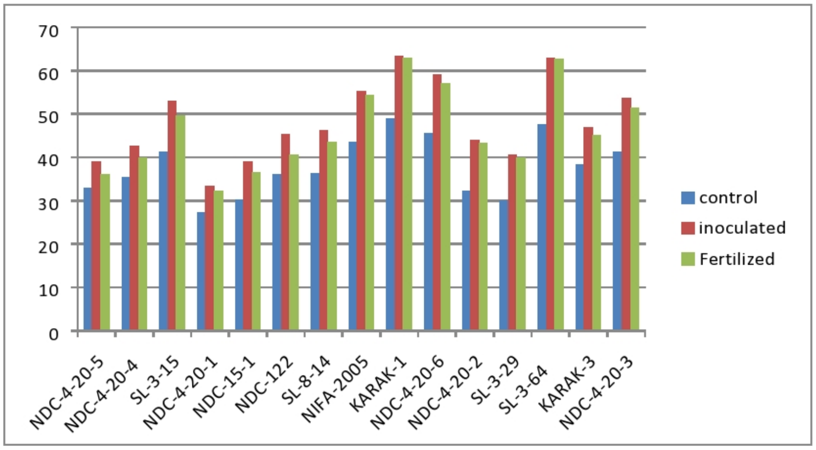

Fig. 3: pod per plant of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer application

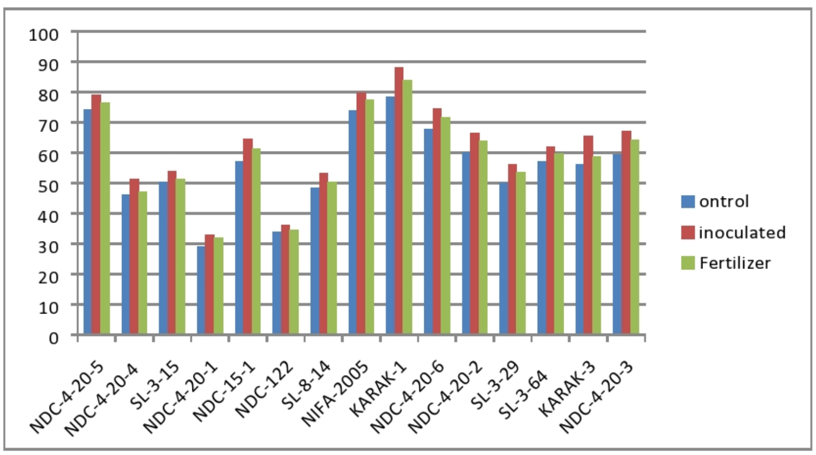

Fig. 4: Seeds per plant of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer application

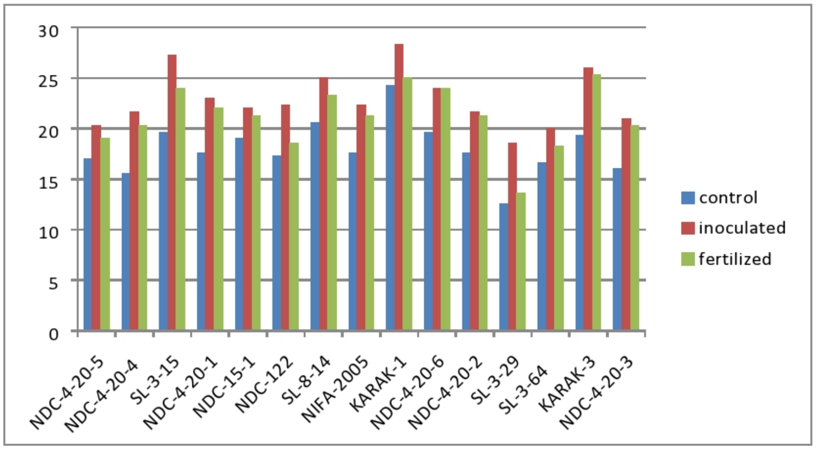

Fig. 5: 100 seed weight of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer application

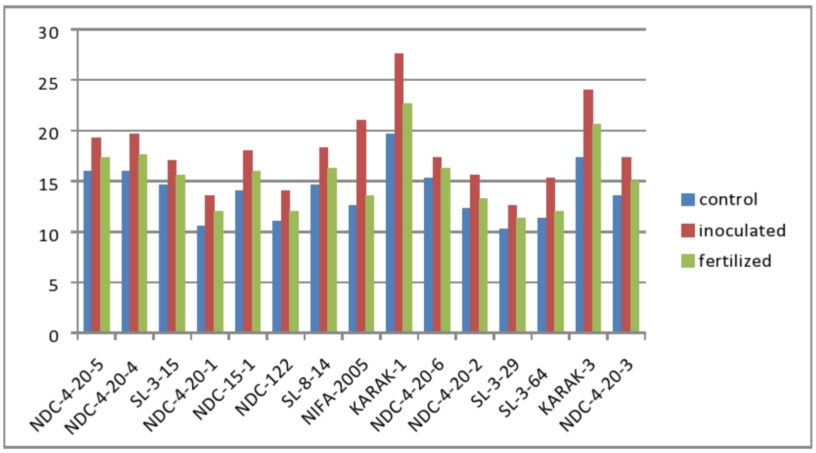

Fig. 6: Seed yield per plant of chickpea genotypes in response to control, rhizobium inoculation and nitrogen fertilizer application

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