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"NOOR-2013" A BOLD SEEDED AND HIGH YIELDING CHICKPEA KABULI VARIETY DEVELOPED INDIGENOUSLY

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ABSTRACT

The evolution of new crop varieties with desirable traits is a continuous process. A crop variety becomes susceptible to various biotic and abiotic plant stresses with the passage of time, thus, necessitating replacement by genotypes possessing better productivity potential and inbuilt tolerance against different stresses. In this perspective, this article reports the progress of a new chickpea kabuli variety "Noor-2013" developed through conventional plant breeding techniques and possesses improved yield potential, extra bold seed size and ability to tolerate different diseases. In 1999-00, two local genotypes, K-96033 (female parent) and K-92029 (male parent) were crossed to create genetic variability for grain size by selecting high yielding recombinants with bold grains. For this purpose, from filial generation one (F_1) seed, an F_2 population was raised and 299 single plant selections (SPS) were made which were advanced to subsequent generations (F_3 to F_5) over the years in plant-to-row progenies using the pedigree method of plant selection. Only high yielding recombinants with bold grains were advanced to the next generations. Finally, a promising uniform line "K-60062" later named as "Noor-2013" with pedigree C.19/19/19/109/148/161/62 was selected from F_6 recombinants during 2005-06. Later, this line was evaluated for yield potential, and disease reaction during 2006-2013. On an average in different yield trials (station, adaptation and national), this strain produced 32.3% higher yield in comparison to check varieties/standards (Punjab-Noor, CM-2008, CM-2000 and Noor-91). In this process, the candidate variety "Noor-13" achieved a potential yield of 3282 kg ha^{-1} in national uniform yield trials (NUYTs) during 2010-11 conducted at Arid Zone Research Institute (AZRI), Bhakkar, Punjab, Pakistan. The grains of this new variety is beige in colour, ram-headed with the 100-grain weight of 34 g. Wider-canopy spread with semi-erect to semi-spread growth habit, bold grains, higher grain yield, resistance to *fusarium oxysporum* and moderately resistance to *ascochyta rabiei* are its salient characteristics. This article concludes that the art of conventional plant breeding still leads the modern era of biotechnology in crop varietal development with desirable traits.

Keywords: Chickpea kabuli, yield potential, bold seed, *fusarium* wilt, *ascochyta* blight.

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INTRODUCTION

Chickpea, a cool-season and self-pollinated (2n=2x=16) legume, belongs to genus *Cicer* that comprises one (1) cultivated and forty-three (43) wild species. It is grown in more than fifty (>50) countries largely on arid to semi-arid tropics and occupies an important position among the food legumes worldwide. Its grains are a rich source of minerals, vitamins, essential amino acids and high-quality protein, which is twice in the amount as of cereals. Its natural ability to improve soil health and to reduce crop nitrogen demands by fixing atmospheric nitrogen (N) through nodulation fits it well in sustainable agricultural production systems (Naveed *et al*., 2015a; Kaloki *et al*., 2019a).

Based on seed characteristics, chickpeas can be categorized into two types' viz., desi and kabuli. Desi types have darker but smaller seeds with rough seed coats, while, kabuli types have larger but lighter coloured seeds with smooth seed coats. Globally, it is now an established fact that lack of genetic diversity in cultivated species, *arietinum*, limit the scope of desired improvement essential for achieving sustainability in chickpea production. Restricted/limited distribution of *Cicer reticulatum* (a wild progenitor), loss of genetic variation associated with domestication (founder effect), and replacement of locally adapted landraces with genetically uniform modern varieties are the major reasons of the narrow genetic base of cultivated chickpea. These issues have also made it vulnerable to various biotic and abiotic stresses. Therefore, concentrated breeding efforts are required for developing and exploiting genetically diverse germplasm (Abbo *et al*., 2003).

Pakistan is an important player in world chickpea acreage (0.98 million hectares), production (330 thousand tonnes), and consumption (324 thousand tonnes). The Punjab province leads with a share of more than 90% in acreage and 80% in production (Anonymous, 2017-18). Chickpea desi which accounts for nearly 85% share in area, is predominantly cultivated in “Thal region” and depends on soil moisture received from pre-season rainfalls, however, chickpea kabuli which is mainly grown on rainfed areas of “Pothowar” and irrigated areas of “Bahawalnagar and Thal” contributes about 15% in area (Haq *et al.*, 2002). In spite of ranking second in world chickpea acreage, the total production of Pakistan is low, unstable and well below the domestic requirements. Therefore, it has to import huge quantity, annually, from the Middle East, Australia and Canada to meet local consumption demands. The bold grains and attractive colour of imported chickpeas are the features, which makes them popular among the consumers.

In Pakistan, various biotic (*fusarium* wilt, *ascochyta* blight etc.) and abiotic (drought, heat, cold etc.) factors when emerging individually or in different combinations become lethal and affect chickpea production, adversely (Naveed *et al*., 2016a, Naveed *et al*., 2019). Wilt, a devastating disease of chickpea in Pakistan, can cause yield losses up to 12 million rupees, annually (Shah *et al*., 2009). It is most prevalent in the subcontinent, and adjoining countries like Burma, Iran and to some extent in Mexico, and Spain (Aslam *et al*., 2013a). Its casual organism, *fusarium oxysporum*, is a root pathogen and transmits through the soil. This pathogen completely blocks xylem vessels, thus, obstructs the food supply to above-ground plant parts (Singh *et al*., 2006). Chickpea blight, on the other hand, caused by *ascochyta rabiei*, develops mostly under moist and humid conditions and can cause yield losses up to 50-70% (Malik and Bashir, 1984). This disease appears only in epidemic form in years, and in countries, receiving higher rainfall during various developmental stages and sometimes may cause complete failure of the crop under severe attack (Bokhari *et al*., 2011).

Development of disease and other stress-tolerant cultivars is the most effective and least expensive way to deal with different yield losses (Shah *et al*., 2010; Sarwar *et al*., 2012; Naveed *et al*., 2015a; Khan *et al*., 2016; Naveed *et al*., 2016b,c; Devasirvatham and Tan, 2018). For this reason, the evolution of new genotypes and release as crop varieties is a continuous process and the ultimate objective of any crop-breeding program (Naveed *et al*., 2016a). The evolution of a new crop cultivar is not a straight-forward process, rather, it is a lengthy process extending up to more than 10 years depending upon the mode of pollination, breeding techniques, selection criterion and many other steps/formalities. These may include selection of parents from screening experiments, attempting different crosses, single plant selections and filial generation advancements, reaction to different stresses (biotic and abiotic), agronomic studies, evaluation for yield and its components, distinguishing uniformity stability (DUS) studies, presenting for spot examination, approval, registration and release for general cultivation by Provincial Seed Council. However, with the passage of time, a variety/genotype becomes vulnerable to many pathotypes resulting in low and unstable yields, thus, demanding replacement with the newer ones possessing inbuilt tolerance and better yield potential.

Local chickpea breeders have made substantial efforts in releasing varieties with improved yield potential and disease tolerance (Arshad *et al*., 2008; Shah *et al*., 2010; Shafiq *et al*., 2011; Aslam *et al*., 2013b). However, all chickpea varieties developed and released so far for general cultivation in Pakistan were medium-to-bold seeded (up to 28g weight of 100 seeds) and until now, no one succeeded in developing chickpea variety with bold grains that could compete with imported chickpeas. With this objective, the presently reported breeding efforts were initiated at Pulses Research Institute (PRI), Ayub Agric. Research Institute (AARI), Faisalabad, Pakistan.

MATERIALS AND METHODS

Based on yield potential, seed size and disease resistance, two strains (K-96033 & K-92029) belonging to kabuli types of chickpea were selected as parents for the purpose of hybridization. Both the parents differ in growth habit, grain size, yield potential and wilt reaction. Entry K-92029 being spreading in nature, bold seeded and wilt resistant used as a male parent while entry K-96033 erect in nature with better yield potential used as the female parent.

Hybridization (F_0): In order to create genetic variability, various crosses were attempted during 1999-00 at the experimental area of Pulses Research Institute (PRI), Faisalabad, Pakistan. In order to facilitate the activity of hybridization, both male and female parents were planted side by side in equal row lengths and by maintaining distances of 30cm P-P and 60cm R-R. From mid-February to mid-March, immature, unopened flowers from female plants were emasculated manually using a forceps followed by pollination (Singh, 1987). The pollen collected from male parent plants were dusted immediately on female parent plants. This was done early in the morning between 9:00 am to 11:00 am to avoid any chance of selfing. Once the crossed flowers successfully developed into pods and attained physiological maturity, they were harvested, thrashed to obtain F_0 seeds. Year by year developmental history of newly approved chickpea kabuli variety is revealed in Table-1.

Advancement of filial generations (F_1 to F_6): During cropping season of 2000-01, F_0 seeds were field planted to raise phenotypically uniform but heterogeneous F_1

hybrid plants. The F_0 seeds were sown inside row of parental lines in equal lengths of 4m by using a dibbler and maintaining standard distances of 20cm and 30cm P-P, and R-R, respectively. The harvested F_1 seeds from every single plant were bulked and used to raise the F_2 population during the next cropping season. Single plant selections (SPS) were made based on desirable characteristics, visually, starting from F_2 generation to subsequent ones leading up to F_5 generation. Bulk and pedigree methods of plant selections were practised during the reported breeding-phase. From F_6 generation, only uniform, true to type pure lines were selected and bulked for further testing in different yield (station, adaptation and national trials), and supporting trials.

General experimental details: During land preparation, one bag of DAP fertilizer at the rate of per acre was mixed in the soil. All practices (agronomic and cultural) like weeding/hoeing, irrigation, and insecticidal spray except entomological trials were kept the same for all the experimental genotypes. The design used was a randomized complete block (RCB) with three replications for all yield, entomological and bacteriological trials. The standard R-R and P-P distances maintained were 30cm and 15cm, respectively. In all the trials, two seeds per hole were placed in order to maintain per plot plant population, which were thinned to one vigorous seedling after 20-25 days of germination.

Yield trials: A plot size of $4\times1.2\ m^2$ was kept uniform for all station (preliminary, advanced) and adaptation (micro, co-operative) yield trials in comparison to $4\times1.8\ m^2$ plot size of national uniform yield trials (NUYTs). Each trial comprised at least one to two checks for evaluating the performance of test entries. Measurements recorded were germination %age, days to 50% flowering (DTF), days to 90% maturity (DTM), pods per plant, 100-seed weight (g), and yield per plot (g). The yield in all the trials was converted into kg ha^{-1} for reporting in an official framework.

Pathological studies: For conducting screening experiments pertaining to *fusarium* wilt and *ascochyta* blight, all the genotypes were laid-out in an augmented design replicated twice with a plot size of 0.3 m^2 for each entry.

Experiments to assess the response of test entries to *fusarium* wilt were conducted on a natural wilt-sick plot maintained by continuously building inoculum of relevant pathotypes. Every two-test entries accompanied by a susceptible check named "AUG-424" on both sides, were planted with a view to build-up the inoculum pressure. All the susceptible lines exhibited hundred-per cent wilt attack, which revealed the highest level of field infestation. The first recording of wilt frequency was done 30 days after sowing followed by 10 days interval between recordings till the crop maturity. The reaction of each genotype to *fusarium* wilt in terms of resistance and susceptibility was determined by following disease-rating scale (DRS) of Iqbal *et al.,* (1996).

For *ascochyta* blight studies, a plastic tunnel with a sprinkler system was used for creating more than 90% artificial mist, conducive for the appearance of *ascochyta* disease. Punjab-1 being used as a spreader/check was planted after every two test-entries in order to record the intensity/severity of the disease. Plants were inoculated by spraying at 8-10 leaf stage, usually during the first week of February, however, scoring was done after about fourteen days of inoculation on 0 to 9 DRS (Shah *et al.*, 2005).

Entomological studies: Gram pod borer is the only insect pest that can cause yield losses up to an economic threshold level. Therefore, these studies were conducted for assessing the percentage of pod borer infestation. For estimating infestation %age, total pods and infested pods per plant were counted and the percentage was worked out.

Bacteriological studies: Field trials were conducted for the assessment of responses of both candidate and check varieties under two treatments of un-inoculation and *rhizobial* inoculation. Measurements were recorded on nodules per plant and grain yield per plant.

RESULTS

Among the various cross combinations attempted during 1999-00, cross number (C. #) nineteen (19) comprising local lines, 96033 and K-92029 revealed maximum F_0 seed settings i.e. 13 seeds. During the next cropping season (2000-01), these seeds were field-planted to raise F_1 generation. Seeds of parental lines were also sown to compare the plant phenotypes of parents and hybrids (F_1). Out of thirteen F_0 seeds, only nine germinated, developed into seedlings and whole plants. On attaining physiological maturity, seeds from nine plants were harvested, thrashed, bulked and labelled as F_1 seeds. Next year i.e. 2001-02, F_2 generation was raised from F_1 seeds by allowing them to self-pollinate. About 299 SPS were made from F_2 plant population. These plant selections were done at 90% pod setting based on plant vigour and pod size. Once matured, each of these plants was harvested, thrashed and their seeds kept separately. Based on seed size and yield per plant, 153 out of 299 single plants were selected for further evaluation in subsequent generations. During cropping season of 2002-03, plant rows in the F_3 generation were raised by planting 153 F_2 SPS on the wilt-sick bed. Most of these plant-rows were destroyed by the attack of *fusarium* wilt, however, among the survived ones, progeny no. 109 revealed wilt resistance, higher and bolder pods, hence greater yield per plant. After harvesting and thrashing, the seeds obtained from this progeny were bulked. During 2003-04, this bulked seed used to sow 161 families of plant-rows under normal soil conditions in the F_4 generation. Regular field visits revealed progeny no. 148 with plants of different growth habits viz., erect, semi-erect, semi-spread, spread but some with medium and others with bold grains. All these SPS were harvested and thrashed separately. However, SPS with bold grains were separated and used to sow 171 plant-row families in F_5 generation during the cropping season of 2004-05. Regular field visits revealed progeny no. 161 largely uniform. The plants were semi-erect to semi-spread in growth habit and with bold pods/seed size. Seeds harvested from this progeny advanced to F_6 generation to plant seventy-nine (79) progeny-rows during the year of 2005-06. Regular field visits were conducted and observations were recorded. It was noticed that the plant types in progeny no. 62 were semi-erect to semi-spread, true-to-type/uniform in appearance, bear greater no. of pods with bold grains. These plants were harvested, thrashed and bulked so that sufficient quantity of seed is available for further testing. In this way, entry K-60062 was evolved and its pedigree can be written as C.19/19/19/109/148/161/62.

Advance line K-60062 was then evaluated for yield potential in a series of trials conducted at different locations and over the years. In these trials, the performance of K-60062 was very good. Yield performance of K-60062 along with checks is presented in Table-2. In station (preliminary and advance) yield trials, candidate line K-60062 produced grain yield in the range of 1129 to 1771 kg ha^{-1}. This is well over the yield performance of checks, Noor -91 (932 to 1528 kg ha^{-1}) and CM-2000 (590 kg ha^{-1} to 1109 kg ha^{-1}). The average yield of 1464 kg ha^{-1} of K-60062 in station yield trials was much higher than the average of 1045 kg ha^{-1} of both check varieties. Table-3 revealed the performance of the candidate and check varieties in adaptation (micro and co-operative) yield trials. In these trials, K-60062 produced grain yield in the range of 649 kg ha^{-1} to 2614 kg ha^{-1} and outperformed checks, Noor-91 (521 to 2270 kg ha^{-1}) and CM-2008 (469 to 2330 kg ha^{-1}). The average yield of 1450 kg ha^{-1} of K-60062 was six mounds higher than the average yield (1210 kg ha^{-1}) of both the checks. Yield performance of K-60062 in national uniform yield trials (NUYTs) is given in Table-3. Similar to station and adaptation yield trials, the performance of candidate variety in NUYTs was also better than Noor-91 and Punjab-Noor, the check varieties. During 2010-11 NUYTs, strain K-60062 achieved a yield potential of 3282 kg ha^{-1} at AZRI, Bhakkar, Punjab, Pakistan. Average of both years NUYTs revealed a yield of 1360 kg ha^{-1} in comparison to the average yield of 1166 kg ha^{-1} of Noor-91 and Punjab-Noor.

The response of candidate variety and standards to different irrigation levels is presented in Table-5. For three irrigation levels i.e. zero, one and two, agronomic and cultural practices including P-P and R-R distances, fertilizer applications were kept the same. Under rain-fed/zero irrigation, the performance of candidate line K-60062 was at par to check cultivars, CM-2008 and Punjab-Noor. However, candidate variety K-60062 responded well to irrigation level one by producing a yield of 1686 kg ha^{-1} in comparison to 1504 kg ha^{-1} of CM-2008 and 1590 kg ha^{-1} of Punjab-Noor. Likewise, K-60062 even responded better to irrigation level two and yielded 2134 kg ha^{-1} in contrast to 1911 kg ha^{-1} of CM-2008 and 2101 kg ha^{-1} of Punjab-Noor. Average of all three irrigation levels revealed a yield of 1695 kg ha^{-1} of K-60062 in comparison to 1606 kg ha^{-1} of both standard cultivars.

The reaction of K-60062 to *ascochyta* blight and *fusarium* wilt is presented in Table-6. These studies were conducted during 2011-13 under a tunnel and wilt-sick bed, respectively. For chickpea blight, both candidate and standard cultivars were placed under scale 5, therefore, declared as moderately resistant (MR). However, against chickpea wilt, K-60062 was placed under scale 3 as resistant (R) while the check variety Punjab-Noor under scale 5 as MR. This information on disease reaction and performance in yield trials confirmed the scope of cultivation of this candidate line on a range of soil types and environments conducive for the development of different diseases.

Entomological studies regarding the infestation of gram pod borer on K-60062 and standard cultivars is presented in Table-7. Data regarding pod infestation %age revealed lesser infestation on K-60062 in comparison to Punjab-Noor. However, these differences were non-significant statistically.

The response of candidate and check varieties to *rhizobial* inoculation (RI) is given in Table-8. The data revealed that the nodules number and yield increased under inoculation in comparison to un-inoculation. Under inoculation conditions, K-60062 produced 16-18 nodules per plant and yielded 1432 kg ha^{-1} to 1769 kg ha^{-1} while Punjab-Noor produced 14-16 nodules per plant and yielded 1374 kg ha^{-1} to 1463 kg ha^{-1}. Similarly, the response of K-60062 under un-inoculated conditions was better than check cultivar. It produced 10-11 nodules per plant and yielded 1109 kg ha^{-1} to 1490 kg ha^{-1} while Punjab-Noor produced 9-10 nodules per plant and yielded in the range of 1090 kg ha^{-1} to 1244 kg ha^{-1}.

Various qualitative and quantitative characteristics of K-60062 in comparison to Punjab-Noor are presented in Table-10. The candidate line revealed differences with the check, Punjab-Noor in stem characteristics like plant height, growth habit, canopy spread, primary and secondary branches per plant. Differences in leaf traits such as colour, leaflets per leaf and leaf hairiness were also recorded. Similarly, distinctiveness was also noticed for reproductive traits such as phenology (days to flowering and maturity), pods (size and number), seeds (colour and 100-seed weight), yield potential and disease reaction.

Table-1. Different stages of selection of K-60062 as "Noor-2013".

Year	Filial generation/trial	Operation
1999-00	Hybridization	F_0 seed harvested
2000-01	F_1	F_1 seed harvested
2001-02	F_2	Single plant selection
2002-03	F_3	Plant to row progenies
2003-04	F_4	-do-
2004-05	F_5	-do-
2005-06	F_6	Uniform line selected and bulked
2006-07	Preliminary Yield Trial	Yield data were recorded
2007-08	Advanced Yield Trial	-do-
2008-09	Micro Yield Trial	-do-
2009-10	Co-operative Yield Trial	-do-
2009-10	National Uniform Yield Trial	-do-
2010-11	National Uniform Yield Trial	-do-
2011-12	Agronomic Studies	Response to different irrigation levels
2011-13	Pathological Studies	Reaction to *fusarium* wilt & *ascochyta* blight
2012-13	Entomological Studies	Infestation of gram pod borer
2011-13	Bacteriological Studies	Response to *rhizobial* inoculation
2013-17	Seed Production (BNS)	Maintenance and supply of breeder nuclear seed to seed companies and farming community

Table-2. Performance of K-60062 as "Noor-2013" in station yield trials (SYT).

Year	Name of Trial / Locations	Yield (kg/ha)			+/- Over checks (%)
		Check (s)		K-60062	
	Preliminary Yield Trial (PYT)				
2006-07	AARI, Faisalabad	CM-2000	1109	1129	1.8
		Noor-91	932		21.1
	Average +/- over checks (%)				*11.5*
	Advanced Yield Trials (AYT)				
2007-08	AARI, Faisalabad	CM-2000	1056	1493	41.4
		Noor-91	1056		41.4
	GBRSS, Kallurkot	CM-2000	590	1771	200.2
		Noor-91	1528		15.9
	Average +/- over checks (%)				*74.7*
	Overall average in SYT		***1045***	***1464***	***43.1***

Table-3. Performance of K-60062 as "Noor-2013" in adaptation yield trials (AYT).

Year	Name of Trial / Locations	Yield (kg/ha)			+/- Over checks (%)
		Check (s)		K-60062	
2008-09	**Micro Yield Trials (MYT)**				
	AARI, Faisalabad	Noor-91	1794	2179	21.5
		CM-2008	2069		5.3
	GBRSS, Kallurkot	Noor-91	2270	2614	15.2
		CM-2008	2330		12.2
	PRSS, Sahowali	Noor-91	817	854	4.5
		CM-2008	469		82.1
	Average +/- over checks (%)				*23.5*
	Co-operative Yield Trials (CYT)				
2009-10	AARI, Faisalabad	Noor-91	567	649	14.5
		CM-2008	549		18.2
	NIAB, Faisalabad	Noor-91	1035	1533	48.1

		CM-2008	1479		3.7
	GBRSS, Kallurkot	Noor-91	521	868	66.6
		CM-2008	625		38.9
	Average +/- over checks (%)				*31.7*
	Overall average in ADYT		***1210***	***1450***	***27.6***

Table-4. Performance of K-60062 as "Noor-2013" in national uniform yield trials (NUYTs).

Year	Locations	Yield (kg/ha)			+/- Over checks (%)
		Check (s)		K-60062	
2009-10	BARI, Chakwal	Noor-91	1708	2097	22.8
	NIAB, Faisalabad		1184	1599	35.1
	ARS, Karak		231	301	30.3
	AZRI, DIK		1694	1942	14.6
	BARS, Sakrand		950	794	-16.4
	GBRSS, Kallurkot		810	1134	40.0
	BARS, Fatehjang		195	220	12.8
	AZRI, Bhakkar		127	338	166.1
	AARI, Faisalabad		472	458	-3.0
	Average +/- over check (%)				*33.6*
2010-11	NARC, Islamabad	Punjab- Noor	3171	2100	-33.8
	BARI, Chakwal		1701	1840	8.2
	AZRI, Bhakkar		1859	3282	76.5
	NIAB, Faisalabad		1460	2092	43.3
	AARI, Faisalabad		1120	1576	40.7
	ARI, Sariab, Quetta		806	630	-21.8
	Average +/- over check (%)				*18.9*
	Overall average in NUYT		***1166***	***1360***	***26.3***

Table-5. The response of K-60062 as "Noor-2013" to different irrigation levels.

Irrigation level	Yield (kg/ha)			+/- Over check (%)
	Checks		K-60062	
Zero	CM-2008	1256	1265	0.71
	Punjab-Noor	1272		-0.55
One	CM-2008	1504	1686	10.8
	Punjab-Noor	1590		5.7
Two	CM-2008	1911	2134	10.5
	Punjab-Noor	2101		1.6
	Overall average	***1606***	***1695***	***4.8***

Table-6. The reaction of K-60062 as "Noor-2013" to *fusarium* wilt and *ascochyta* blight.

***Fusarium* wilt**			***Ascochyta* blight**		
Grade	**Reaction**	**Genotypes**	**Grade**	**Reaction**	**Genotypes**
1	Highly Resistant	-	**0**	Immune	-
3	Resistant	K-60062	**1**	Highly Resistant	-
5	Moderately Resistant	Punjab-Noor (check)	**3**	Resistant	-
7	Susceptible	-	**5**	Moderately Resistant	K-60062 Punjab-Noor (check)
9	Highly Susceptible	-	**7**	Susceptible	-
			9	Highly Susceptible	-

Table-7. The infestation of gram pod borer on K-60062 as "Noor-2013".

Entries	No. of pods studied	Infested pods	%age infested	Yield (kg/ha)
K-60062	82	6	7.1a	1498a
Punjab-Noor (check)	84	6	7.3a	1244b

Table-8. The response of K-60062 as "Noor-2013" to *rhizobial* inoculation.

Treatment	Trait	2011-12		2012-13		Average
		Punjab-Noor	K-60062	Punjab-Noor	K-60062	
Un-inoculation	*No. of*	9	11	10	10	**10**
Inoculation	*Nodules*	16	18	14	16	**16**
Un-inoculation	*Yield*	1244	1490	1090	1109	**1233**
Inoculation	kg/ha	1463	1769	1374	1432	**1510**
	+/- Yield (%)	***17.6***	***18.7***	***26.1***	***29.1***	***22.9***

Table-9. Production of basic nuclear seed (BNS) of Noor-2013.

Year	2013-14	2014-15	2015-16	2016-17
Quantity (kg)	695	940	675	830

Table-10. Agronomical, morphological and qualitative plant traits of K-60062 as "Noor-2013" in contrast to the check, Punjab-Noor (Av. five years 2006-11).

	Traits	K-60062	Punjab-Noor
a	**Stem**		
1	Plant height	60-65cm	60cm
2	Growth habit	Semi erect to Semi-spread	Semi erect
3	Canopy spread	Wide	Medium
4	Stem colour	Light green	Light green
5	Primary branches	7-11	6-10
6	Secondary branches	8-15	8-12
b	**Leaf**		
1	Leaf colour	Green	Waxy / light green
2	Leaflets per leaf	15-17	15
3	Leaflets size	Large	Large
4	Leaf hairiness	Medium	Absent
5	Days to 90% flowering	110-115	115-120
c	**Pods**		
1	Pod size	Large	Large
2	Shattering	Absent	Absent
3	Pods per plant	40-70	45-50
4	Seeds per pod	1-2	1-2
5	Days to maturity	155-160	165-170
d	**Seeds**		
1	Seed shape	Ram's head	Ram's head
2	Seed colour	Beige	Beige
3	100 seed weight	34 gm	25 gm
e	**Yield** (kg ha^{-1})		
1	Yield potential (NUYT)	3282 (AZRI, Bhakkar)	3063 (AARI, Fsd)
2	Average yield (NUYT)	1360	1319
	Adaptive areas	All Punjab	All Punjab

Figure-1. The grains of Noor-2013

DISCUSSION

The progress made during the 20th century in the field of agriculture especially plant breeding and in developing new crop varieties with desirable characteristics is exceptional. The art of spotting distinctive and desirable traits and incorporating them into new or genotypes of interest is the main feature of conventional/traditional plant breeding (Maqbool *et al*., 2017). Since its practice dating back to human civilization, the contributions made over the years by this aspect of plant breeding towards sustainable agricultural production systems are over-whelming (Poehlman *et al*., 1995; Kaloki *et al*., 2019b). For instance, several chickpea cultivars (NIFA-88, Noor-91, Bittal-98, CM-98, CM-2000, Punjab-2000, Thal-2006, Punjab-2008, CM-2008; Punjab-Noor, and Bhakkar-2011) in Pakistan and India (JGK-1 and PBG-2) were developed using this system (Hassan and Khan, 1991; Ali, 1999; Haq *et al*., 1999, 2002; Ali *et al*., 2004; Gaur *et al*., 2004; Sandhu *et al*., 2004; Shah *et al*., 2010; Shafiq *et al*., 2011; Aslam *et al*., 2013b). The latest chickpea kabuli variety, Noor-2013, developed through this technique performed exceptionally well and consistently out-yielded checks during its evaluation phase. On average, Noor-2013 surpassed respective checks by 43.1% higher yield in station yield trials, with 11.5% in PYT and 74.7% in AYT. In adaptation or multi-location yield trials, the candidate line produced 23.5% higher yield in MYT and 31.7% in CYT. During both years of national testing, this strain produced 33.6% higher yield in 2009-10 and 18.9% in 2010-11 over the checks, suggesting its adaptation and yield potential over a range of environmental conditions (Yadav *et al*., 2010). Furthermore, a candidate variety has to out-perform competing checks consistently for its approval and the results of Noor-2013 are in accordance to previously approved chickpea varieties (Shafiq *et al*., 2011; Aslam *et al*., 2013b).

Among the various agro-morphological traits of Noor-2013, its plant height ranged 60-65cm with light green stem colour and spreading type (semi-erect to semi-spread) growth habit. It has a wider canopy with 7-11 primary branches and 8-15 secondary branches. It has large leaflets with 15-17 greenish leaflets per leaf and medium pubescence (hairiness). It takes 110-115 days for 90% flowering and 155-160 days for physiological maturity. It has 40-70 pods per plant, with 1-2 seeds per pod. Pods are larger while shattering is absent. Its seeds are ram-headed, beige in colour with a 100-seed weight of 34 g (Figure-1). The most important genetic improvement in this strain over previously approved chickpea cultivars is bold-seeded grain, inbuilt resistance (R) against *fusarium* wilt and moderate resistance (MR) against *ascochyta* blight. The bold-seeded trait is considered very important in ultimate crop productions and consumer preferences (Hassan and Khan, 1991; Waldia *et al*., 1996; Ali *et al*., 1999; Mehla *et al*., 2000; Sandhu *et al*., 2004; Shah *et al*., 2010; Naveed *et al*., 2015a). Noor-2013 revealed adaptation throughout Punjab, Pakistan with a yield potential of 3282 kg ha^{-1} and an average yield of 1360 kg ha^{-1}. Regarding yield performance at the national level, this strain was among the top positions in NUYTs conducted during 2009-10 and 2010-11. Regarding ideotype of Noor-2013, it is ideal for cultivation in rain-fed and irrigated areas and for mechanical harvesting.

The ultimate crop production depends upon a number of factors, and seeding at the optimum time is one of them (Naveed *et al*., 2015b). For Noor-2013, data revealed that sowing during last-week of October to mid-November along with an application of nitrogen (N) fertilizer @ 25-50 kg ha^{-1} and phosphorus (P) fertilizer @ 60-90 kg ha^{-1} at the time of land preparation is best for achieving maximum production. Furthermore, seeding at a depth of 15 to 20cm is recommended for good germination under water-deficit conditions, however, for a healthier crop, a distance of 15cm P-P and 30cm R-R should be maintained.

As far as genetic purity is concerned, Noor-2013 is regularly maintained at Pulses Research Institute (PRI), Faisalabad and its Substation (Gram Breeding Research Substation) at Kallurkot, Bhakkar, Pakistan. Since 2013 to 2017, breeder nuclear seed (BNS) was supplied to chickpea growers and different seed producing agencies/companies for its better and effective adoption (Table-9). The Punjab Seed Council (PSC), Lahore approved this new strain “K-60062” under label "Noor-2013" for commercial cultivation throughout Punjab, Pakistan.

Conclusions: Noor-2013 is a high yielding, bold seeded chickpea kabuli variety with inbuilt tolerance against major diseases of chickpea (*fusarium* wilt and *ascochyta* blight). This variety proved its worth consistently in station, adaptation and national yield trials and out-yielded check varieties significantly. It is expected that Noor-2013 due to its desirable features will gain popularity among the farming community. Adoption of this variety in terms of seed multiplication and cultivation at farmer’s field will surely contribute to sustaining, stabilizing and improving domestic chickpea production and in reducing ever-increasing chickpea import bill of Pakistan.

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