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Short note

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Field evaluation of new Kabuli chickpeas lines for the production of canned seeds

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Abstract: There is an increased demand for canned chickpeas worldwide, which has also resulted in increased chickpea cultivation in Italy. The availability of Italian chickpea varieties, suitable for industrial transformation, is limited. The objective of the present study was to evaluate the field production of new Kabuli chickpea accessions and their suitability for industrial transformation. Thirteen accessions, provided by the International Centre for Agricultural Research of Turkey, together with 'Blanco Sinaloa', a commercial Mexican variety, were cultivated in Cesa, Tuscany, in 2016 and 2017. The average seed yield was 2.8 and 3.4 t ha^{-1}, respectively, in 2016 and 2017. Increased yield in 2017 was attributable to a more balanced rainfall pattern, compared to that in 2016 which induced increased vegetative growth. Based on production stability over the two-year trial, the varieties FLIP08-69C, FLIP-160C and FLIP05-157C turned out particularly suitable for cultivation. The climatic conditions in 2017 favored an increased presence of a Grade B seed classification [220-250 seeds per 100 g (caliber 8)] which is preferred by industry. Most varieties showed potential regarding seed dimension classification, however, of the varieties with a good production, FLIP05-157C was also characterized by seed gradation stability.

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All relevant data are within the paper and its Supporting Information files.

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The authors declare no competing interests.

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1. Introduction

In recent years, there has been a change in the style of food consumption by Italian people. This includes the growing interest in legumes as an alternative protein source to meat. The lower fat content of legumes appears to be a more appreciated characteristic. Here, we are referring to "food safety", where consumers are prepared to incur higher costs when purchasing foods for health safety and towards guaranteeing environmentally friendly production techniques (Dixon and Sumner, 2003; Fratianni *et al*., 2014).

The industrial uses of legumes vary, ranging from animal feed (flour and supplements) to the processing of the seeds for human consumption, especially in the form of preserved (canned) products.

According to 2016 statistics, the Italian market for canned vegetables is valued at approximately 400 million Euros, representing an increase of +1.2% compared to the previous year (Limonta, 2016). The same data showed that, in the face of production decreases in sweet corn, green beans and peas, there is an increase in beans and chickpeas. More specifically, the categories "beans" and "other legumes" (chickpeas and lentils) constitute more than 60% of the market. As regards chickpeas, with a 62% share, an increase of 10.2% was recorded.

As an inevitable consequence, there was an increase in the area dedicated to chickpea cultivation in Italy (Palumbo, 2017), from 5.000 to almost 16.000 ha, from 2008 to 2017, respectively. This notable increase is attributable, not only to the aforementioned food trends, but also to agronomic benefits such as reducing the use of both fertilizers and pesticides. In turn, this serves to improve the structure and fertility of the soil and, above all, a more sustainable return to crop rotation with cereals (Palumbo, 2017). These benefits were already sought after, as early as the beginning of 2000 (Watson *et al*., 2017). Concomitant with Italian scenario for chickpea cultivation, there has been a steady increase in the world production of chickpeas from 63.4 to 77.5 million tons, from 2009 to 2015, respectively (Muehlbauer and Sarker, 2017).

This positive trend in the chickpea market has naturally resulted in the involvement of the Italian canning industry, always attentive to the needs of the market. An increasing number of industries, through their own incentive, are producing the raw material directly in Italy just to meet the needs of "Food safety". In this way, through cultivation contracts, they are certain to direct cultivation towards the production of the raw material, adhering, as closely as possible to both product requirements and processing techniques for the production of canned chickpeas. The Italian consumer prefers Kabuli chickpeas. The characteristics of "Kabuli" include a light color, preferably with a caliber of 8 (220-250 seeds per 100 g), a typical shape with rough surface, and with a thin integument that still adheres to the seeds once cooked (Palumbo, 2017).

The availability of Italian chickpea varieties, suitable for industrial transformation, is rather limited. With regard to Central Italy, more specifically Tuscany, experimental tests conducted in the '80s and '90s (Casini, 1987, 1989), showed that either autumn or end of winter sowing subjected the cultivation to high risks of Anthracnose [*Ascochyta rabiei* (Pass.) Labr. Trot.]. More recent research (Radicetti *et al*., 2012), has highlighted that "Pascià" and "Principe" are the two most widespread Italian varieties, suitable for industrial transformation with yields varying between 2.5 and 2.7 t ha^{-1}. However, industry is continually looking for new varieties either for use in genetic improvement programs or for use towards better production, tolerance to diseases and technological qualities.

The aim of the present study was to evaluate the field production of new accessions of Kabuli chickpeas and their suitability for industrial transformation based on the preferred seed dimensions classification characteristics.

2. Materials and Methods

The field experiments were carried out in Tuscany, Central Italy, in 2016 and 2017 at the "Centro per il Collaudo ed il Trasferimento dell'Innovazione di Cesa (Arezzo)", 43° 18' N; 11° 47' E; 242 m a.s.l. The cultivation environment was characterized of a neutral, loamy-sandy soil. The principle physical and chemical characteristics of the soil were as follows: sand 36%, loam 38%, and clay 26% respectively. The soil pH was 7.0. Total N was 0.11% and P (Olsen) 13 ppm. Exchangeable Ca, Mg and K were 4123, 595 and 141 ppm, respectively.

Thirteen accessions, provided by the International Centre for Agricultural Research (ICARDA) of Ankara (Turkey), were used, in addition to "Blanco Sinaloa", a commercial variety from Mexico. Based on previous experiments carried out in Central Italy (Casini, 1989), the Autumn-Winter sowing period was not taken into consideration due to serious damage caused by Anthracnose blight. As a result, the sowing dates were March 14, 2016 and February 22, 2017, respectively. Plots were arranged according to a complete RCB design, with three replicates. The size of the plots were 2.0 x 4.0 m (four rows wide with 0.5 m row spacing). The sampling area was comprised of the two central rows of 3.0 m long. A seed quantity of 380 per plot was used. In order to obtain the correct planting density of 25 plants m^{-2}, seedlings were thinned soon after complete emergence. Plots were hand-weeded twice (45 and 65 days after emergence

[DAE]) during the growth cycle. The agricultural interventions performed during the two-year experimental period are reported in Table 1. Plant height, number of stems, height of the first pod and number of pods per plant were determined at maturation stage, using a total of 10 plants per sample plot. Yield calculation and the number of seeds amounting to 100 g were performed using seed samples at standard humidity of 12%. Grading of seeds was carried out according to the standard tables of Conserve Italia (2015) for the Italian market as follows: Grade A [<220 seeds per 100 g (caliber 6)]; Grade B [220-250 seeds per 100 g (caliber 8)] and Non Standard or Off-Type (>250 seeds per 100 g). Both Grades A and B are considered suitable for processing, but B is the preferred grade.

Table 1 - Agronomic technique, date of sowing, date of emergence and harvesting of the two field trials

	2016	2017
Previous crop	Wheat	Sunflower
Plowing	September 6, 2015	-
Rippering and rolling	-	October 22, 2016
Harrowing	September 28, 2015	November 2, 2016
Grubbering	-	January 10
Harrowing	March 14	February 22
Pre-sowing fertilization	March 14	February 22
	N 52 and P_2O_5 114 kg ha^{-1}	N 52 and P_2O_5 114 kg ha^{-1}
Sowing	March 15	February 23
Emergence	April 11	March 14
Harvesting	August 22	August 19

Data collected in the experiments were processed utilizing a mixed-model analysis of variance (ANOVA), where accession was considered as a fixed effect factor, and year as random effect factor. Statistical differences were tested at P≤0.05, P≤0.01 or P≤0.001. The Tukey's HSD test was used to stress significant differences between means and homogenous groups.

3. Results, Discussion and Conclusions

The climatic trends over the two-year experimental period were very different, especially with regard to rainfall. In the first year, the crop benefited from 562 mm of rainfall, of which 142 mm were evenly distributed during the period May-mid-June. In the second year, total rainfall over the cultivation cycle was 290 mm. In 2017 the maximum temperatures were particularly high with an average of 24.8°C (31.0°C in the summer).

Principle biometric characteristics of the lines (Table 2) were significantly different at either p≤0.01 or p≤0.001, with the exception of the number of empty pods per plant. As regards the main biometric characteristics, the higher rainfall of 2016, contributed to a greater vegetative growth of the plants, compared to that in 2017. The height of the plants

Table 2 - Principle biometric characteristics of the lines

Source of variation	Plant height (cm)	Stems per plant (n)	Height of first pod (cm)	Filled pods (n)	Empty pods (n)	Seeds per pod (n)
Lines (L)						
FLIP05-69C	58.3 a	5.1 bcd	34.3 a	43.5 bc	3.5 a	1.2 ab
FLIP05-156C	55.1 ab	5.3 a-d	28.2 bcd	45.6 bc	4.9 a	1.1 ab
FLIP05-157C	53.9 ab	6.7 ab	29.2 bc	39.1 cd	3.4 a	1.1 ab
FLIP07-230C	58.7 a	6.9 a	30.7 ab	45.1 bc	5.0 a	1.1 ab
FLIP07-318C	52.7 ab	5.5 a-d	30.0 abc	42.0 cd	3.0 a	1.3 a
FLIP08-69C	55.7 ab	6.6 ab	28.9 bcd	48.5 bc	3.9 a	1.2 ab
FLIP08-160C	52.6 ab	6.2 abc	29.3 bc	47.2 bc	4.4 a	1.1 ab
FLIP08-170C	56.8 a	5.1 bcd	27.5 bcd	58.5 a	4.5 a	1.2 ab
FLIP08-200C	55.4 ab	4.7 cd	25.8 cde	43.7 bc	4.9 a	1.2 ab
W6-12861	59.0 a	6.0 a-d	31.3 ab	63.3 a	4.9 a	1.1 ab
W6-9484	54.9 ab	5.1 bcd	24.3 de	37.2 cd	4.3 a	1.0 b
W6-30	54.0 ab	5.7 a-d	25.4 cde	46.2 bc	4.1 a	1.0 b
W6-25	52.4 ab	4.5 d	28.0 bcd	57.2 ab	4.6 a	1.2 ab
Blanco Sinaloa	49.1 b	5.1 bcd	21.4 e	29.4 d	2.6 a	1.2 ab
f	**	***	***	***	NS	**
Year (Y)						
2016	42.1	6.7	31.8	65.8	5.8	1.2
2017	42.9	4.6	24.5	28.0	2.4	1.2
f	**	**	***	***	***	NS
L x Y	***	**	***	***	***	NS

NS= not significant; ** significant at P≤0.01; ***significant at P≤0.001.
Means followed by the same letter(s) are not different for P≤0.05 according to Tukey test.

was almost 20 cm higher (average of 64.7 cm) with a corresponding increased height of first stage pods (31.8 cm from the ground), more favorable for mechanical harvesting. Increased vegetative growth was also expressed in the greater ramification number of 6.7 stems per plant in 2016 as compared to 4.6 in 2017, respectively. The height of the plants was both positively and significantly correlated to the number of full pods per plant (r^2 = 0.799**), which in the first year was more than double than that observed for the second year: 65.8 vs. 28.0 cm, respectively.

The average seed yield was 2.8 and 3.4 t ha^{-1}, respectively, in 2016 and 2017 (Fig. 1). The yield increases in 2017 were observed for all varieties. Varieties showing a yield increase that exceeded 25% included FLIP 69C, W6 12861, W6 9484 and W6 25, respectively. These increases were attained despite a lower production of full pods per plant in 2017. This yield increase was likely attributable to the more favorable climatic conditions of 2017, in comparison to those of 2016, which induced increased vegetative growth.

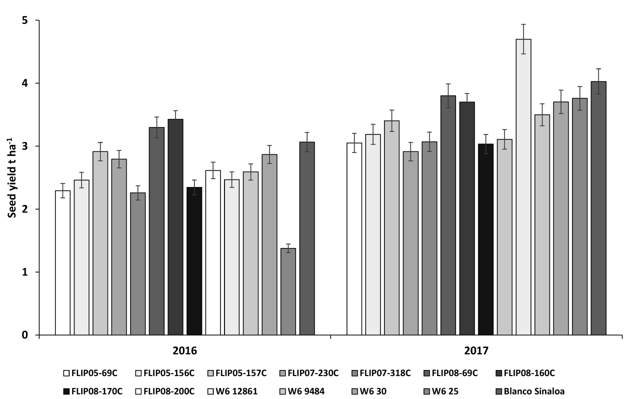

Fig. 1 - Seed production of tested lines in 2016 and 2017

Table 3 shows an increase in the number of seeds per each 100 g weight for almost all varieties, with the exception of W6 25, in which the number seeds (195-196 seeds per 100 g) is maintained. Table 3 also provides the commercial classification values for varieties and their suitability for processing into pre-cooked products. In this regard, all the lines were found to be suitable for both years with a grade classification of either A or B, with the prevalence of the more desired latter classification in 2017.

The results of this experiment highlighted a good production capacity of the majority of the lines tested. Some varieties, such as FLIP08-69C, FLIP-160C and FLIP05-157C, are particularly suitable, as based on production stability over the two-year trial. Moreover, among these lines, FLIP05-157C was also characterized by seed gradation stability, suitable for industrial transformation. Conditions of balanced rainfall, evident in 2017, favored an 8 caliber (B) seed yield, which is preferred by industry.

In conclusion, with some exceptions, all the lines tested are considered suitable for use in selection and/or for breeding programs, aimed at obtaining varieties dedicated to the production of pre-cooked seeds for the Italian market.

Table 3 - Number of seeds per 100 g and the corresponding grade for canned products

Lines	2016		2017	
	Seeds per 100 g (n)	Grade	Seeds per 100 g (n)	Grade
FLIP05-69C	241 ab	B	232 ab	B
FLIP05-156C	236 ab	B	243 ab	B
FLIP05-157C	233 ab	B	238 ab	B
FLIP07-230C	229 bc	B	224 bcd	B
FLIP07-318C	219 cd	A	231 bc	B
FLIP08-69C	202 e	A	240 ab	B
FLIP08-160C	200 ed	A	245 a	B
FLIP08-170C	215 cd	A	238 ab	B
FLIP08-200C	219 cd	A	246 a	B
W6-12861	216 cd	A	231 bc	B
W6-9484	198 ed	A	229 bc	B
W6-30	195 d	A	196 ed	A
W6-25	225 bcd	B	231 bc	B
Blanco Sinaloa	198 ed	A	229 bc	B

Means followed by the same letter(s) are not different for P≤0.05 according to Tukey test.

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