Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 1, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INFLUENCE OF TILLAGE AND VARIETY ON YIELD AND QUALITY OF CHICKPEA CROP ON THE REDDISH PRELUVOSOL FROM MOARA DOMNEASCĂ, ROMANIA

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Abstract

In grain legume crops, cultivated varieties and basic tillage are the first important factor for improving yield and quality indicators, especially in recent years when climate change has induced long dry periods during the growing season. Thus, the research focused on the influence of tillage and chickpea varieties on production, productivity elements and quality indicators in the reddish preluvosol zone, knowing the less favorable characteristics of the soil type. The research was carried out over two agricultural years period respectively, 2022-2024 under climatic environment of Moara Domneasca, Ilfov county. Three tillage variants were evaluated: plowing at 25 cm depth, chiseling at 35 cm depth and disc harrowing at 12 cm depth and 4 chickpea varieties: Burnas, Rodin, Flamenco and CDC Orion. The results obtained showed differences between the varieties of chickpeas taken in the study but especially between the tillage. The highest yield was obtained by CDC Orion variety in the experimental trial in which the soil was ploughed, but Flamenco variety had a higher protein and lipid content in the kernels.

Key words*: chickpea varieties, tillage, yield, quality.*

INTRODUCTION

The chickpea is the grain legume crop with an increasing global demand in recent years (Grasso et al., 2022). It is recommended in sustainable agriculture because it requires less water amount and improves soil characteristics (Millán et al., 2015).

Chickpea is suitable in crop rotation causing an increase in soil fertility, being a very good previous crop for winter cereals by biological nitrogen fixation from the *Rhizobium leguminosarum* subsp. *ciceri* bacteria symbiosis (Moldovan and David, 2010; Singh and Singh, 2018; Gebremariam and Tesfay, 2021). This limits the negative effect on environment and soil by reducing the quantities of chemical fertilizers per hectare.

Another very important quality of chickpeas is due to its protein quality, being one of the best in the grain legume family (Sotelo et al., 1987). It has an amino acid composition characterized by a high content of leucine, lysine, valine, isoleucine and with amino acids in lower amount as cysteine and methionine (Gutium and Ciumac, 2012).

Chickpea kernels are rich in many nutrients such as: good quality protein around 23.81%, fat around 6.57%, sugars around 3.94%, starch around 50.36%, cellulose around 9.01% (Gutium and Ciumac, 2012) but also contain antinutritional elements around 3.10% (Sotelo et al., 1987). Besides these, the kernels contain iron, potassium, magnesium, calcium, phosphorus, zinc, vitamin B complex, vitamin C and vitamin K and are high in fiber (Jukanti et al., 2012). More than nutritional importance, chickpea kernels have remarkable medicinal properties, enrich blood and cure skin diseases (Warrier et al., 1995). They also have antihelmintic properties and settle the functioning of the digestive tract (Sastry and Kavathekar, 1990; Pittaway et al., 2006; Zia-Ul-Haq et al., 2008).

In grain legume crops, cultivars and tillage are the main important factors for improving yields and quality indicators, especially in recent years due to climatic changes inducing long dry periods during the growing season.

Tillage practices change soil physical properties as soil structure, mechanical impedance, dry bulk density, thermal conductivity, pore size distribution, water distribution, root distribution and production output (Comia et al., 1994; Abu-Hamdeh, 2000; Tapela & Colvin, 2002; Barzegar et al., 2003). Each tillage operation is effective in the soil in different ways. Changes in soil physical properties that increase the pore space lead to improved crop performance but with no tillage they are reduced (Barzegar et al., 2003).

Adequate strategies are essential to optimize the potential and benefits of chickpea varieties from diverse agro-ecological environments and incorporated them into other cropping systems. Lack of adequate information, often leads to their placement in the wrong target regions, where they have had partial success (Shiyani et al., 2002).

The research focused on the comparison of different chickpea varieties and different tillage systems on yield, productivity and quality indicators under pedoclimatic conditions at the Moara Domnească Agronomic Didactic Station, Ilfov County, in the reddish preluvosoil zone. Four chickpea varieties were assessed: Burnas, Rodin, Flameco and Orion and three tillage variants: plowing at 25 cm depth, chisel at 35 cm and disk harrow at 12 cm.

MATERIALS AND METHODS

Research was carried out during 2023 and 2024, at the Moara Domnească Agronomic Didactic Station, Ilfov County. The experimental field was located on different plots depending on the year, the geographical coordinates where the experiment was located. For 2023 it was 44,50294 latitude N and 26,24996 longitude E, and for 2024 was 44.500665 latitude N and 26,249435 longitude E, on the soil type reddish preluvosol belonging to the luvisol class, which is dominant in this region. The research on this soil type are important because the less favorable characteristics of the soil type are known, in this case with a high clay content above 32% and low humus content near 2.2%, a moderately acidic pH around 5.4 and with a low water permeability, with crust forming immediately after precipitation (Mihalache et al., 2009; Mihalache et al., 2010; Mihalache et al., 2014).

The experiment was conducted in a randomized block design with 3 replications, with 12 variants with an experimental area of 21 m^2. The experimental variants consisted of plow at 25 cm depth, chisel at 35 cm depth and disk harrow at 12 cm depth, on which Burnas, Rodin, Flameco and Orion varieties were sown.

The chickpea varieties used in the study have different origins, so Burnas and Rodin are of Romanian origin. They were obtained at Agricultural Research and Development Station Teleorman and approved in 2006, being suitable for growing in arid areas of our country. Research carried out in south-western Romania showed a high raw protein content in Burnas variety around 24.9% and in Rodin around 23.8% (David et al., 2010). The chickpea variety Flamenco has French origin registered in 1991. It is a highly plant dropping and grain shattering resistant, anthracnose resistant, drought and cold tolerant variety with high yield potential and high protein content. The Orion variety is of Canadian origin registered in 2010 and developed by the Crop Development Centre, University of Saskatchewan (Taran et al., 2011). It is a large grain size variety being visually appealing for market marketing. It is highly drought resistant, anthracnose tolerant and has a very high yield potential.

Tillage was done in late November and sowing of the chickpea varieties was done on April 3 in 2023 and March 29 in 2024. Before sowing, the soil was tilled with the cultivator. The chickpea varieties taken in the study were sown after the winter wheat crop, at a density of about 40 plants/m^2, row spacing of 50 cm and an average depth of 5 cm.

The determination of proteins (%) and lipids (%) was carried out in the Phytotechnics Laboratory of the Faculty of Agriculture, USAMV of Bucharest, using an infrared spectrophotometer, Instalab NIR Product-Analizer. The analyzed samples were uniformly ground using a laboratory mill and determined on the same day. Measurements for the quality indicators as 1000 seeds weight (TSWG) and hectoliter weight (HW) were carried out in the Agrotehnics laboratory of the Faculty of Agriculture, USAMV of Bucharest.

Weight per 1000 kernels (TSWG) is a quality indicator for the chickpea crop because large-sized chickpeas are often required.
Productivity indicators such as number of main branches, number of pods/plant, number of kernels/plant, number of kernels/pod, and weight of kernels/plant (g) were determined.
Statistical data were interpreted by analysis of variance, and LSD 5% was used to perform multiple comparisons (Săndoiu, 2020).

RESULTS AND DISCUSSIONS

In terms of precipitation during growing season (March to August), in 2023, chickpeas crop benefited 242 mm, that was a dry year compared to the multi-year average recorded in Romania. In the first month of the growing season precipitation level was very low at only 14 mm but the following April was better with 72.5 mm. The months of May and June did not bring satisfactory rainfall while temperatures were high, these were 32.5 and 32 mm. A total of 91 mm was accumulated for the months of July and August.

Rainfall during the growing season of the 2024 was identical to the previous year in terms of total precipitation, totalling 241.1 mm, but it was distributed differently. In the first part, the rainfall amount was favorable with 59.5 mm in march and 43 mm in April, but after that the drought occurred, with 22.2 mm in May and 15 mm in June. The hot summer months of July and August amounted to 101.4 mm (Figure 1).

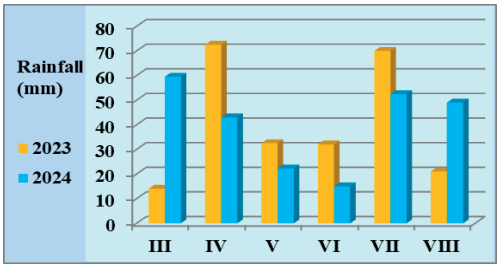

Figure 1. The evolution of rainfall at Moara Domnească, 2023-2024

Regarding temperatures, the two years were roughly similar, with very high temperatures and serious drought. The highest recorded temperatures were in August for the year 2023 and in July for the year 2024 with average monthly temperatures of 26.8 and 26.9°C respectively. The year 2024 had higher temperatures in June of 25.9°C compared to 21.7°C for the year 2023 (Figure 2).

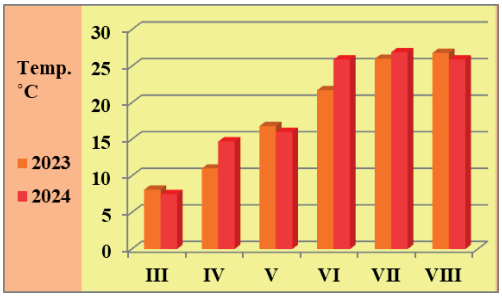

Figure 2. The evolution of temperature at Moara Domnească, 2023-2024

Due to unevenly distributed rainfall shortages in 2023 and 2024, as well as extremely high growing season temperatures above the annual average recorded at the station, the chickpea crop was affected by the water deficit. The chickpea crop is tolerant to arid weather, but for high yields, rainfall needs to be favorably distributed.
The results on the influence of cultivated variety and tillage on yield of chickpea crop of the research years 2023-2024 are shown in Table 1. From the data analysis, it can be noted that yields varied greatly in terms of tillage and less in terms of cultivated varieties. The crop years 2023-2024 were dry and the yields obtained were not high. The average yield of the cultivated varieties for the variant where the plowing was used, was 1566.0 kg/ha. Comparing with the chisel variety, where the average yield of the varieties was 1319.3 kg/ha and the disk variety 759.5 kg/ha, we can say that the yield of the basic plowed tillage was satisfactory in such conditions of drought.
The yield differences between plow, chisel and disking were -246.7 kg/ha and -806.5 kg/ha, being highly significantly negative. The 25 cm deep plowing plot benefited more from soil moisture at sowing time.
Comparing the yields of the studied varieties, the Orion variety had an average yield of 1272.8 kg/ha and in the plowed version being 1654.0 kg/ha, very significantly higher than the Burnas variety. The Flamenco variety had an average yield of 1265.8 kg/ha and with a very significant yield in the plowed variety of 1636.0 kg/ha. The

Burnas and Rodin varieties gave slightly lower average yields of 1163.8 kg/ha and 1157.2 kg/ha and with 1501.5 kg/ha and 1472.5 kg/ha respectively, in the plowed version.

In all tillaged variants, Orion and Flamenco performed the highest yields, with average yield difference of 109.0 and 102.0 kg/ha respectively, more than the reference variety Burnas.

Table 1. Influence of cultivated variety and tillage on chickpea yield, average of research years 2023-2024

No. crt.	Tillage	Variety	Yield		Dif. kg/ha	Significance
			kg/ha	%		
1	PLOWING	Burnas	1501.5	100.0	-	-
2		Rodin	1472.5	98.1	-29.0	-
3		Flamenco	1636.0	109.0	134.5	***
4		Orion	1654.0	110.2	152.5	***
Plowing average			**1566.0**	**100.0**	-	-
5	CHISEL	Burnas	1267.5	100.0	-	-
6		Rodin	1276.0	100.7	8.5	-
7		Flamenco	1357.5	107.1	90.0	***
8		Orion	1376.0	108.6	108.5	***
Chisel average			**1319,3**	**84.2**	**-246,7**	ooo
9	DISC HARROW	Burnas	722.5	100.0	-	-
10		Rodin	723.0	100.1	0.5	-
11		Flamenco	804.0	111.3	81.5	***
12		Orion	788.5	109.1	66	**
Disc harrow average			**759,5**	**48.5**	**-806.5**	ooo
Varieties average		**Burnas**	**1163.8**	**100.0**	-	-
		Rodin	**1157.2**	**99.4**	**-6.6**	-
		Flamenco	**1265.8**	**108.8**	**102.0**	***
		Orion	**1272.8**	**109.4**	**109.0**	***

Factor A: LSD 5% = 66.98 kg/ha; LSD 1% = 113.34 kg/ha; LSD 0.1% = 195.78 kg/ha.
Factor B: LSD 5% = 24.67 kg/ha; LSD 1% = 33,61 kg/ha; LSD 0,1% = 49.76kg/ha.
Factor A1/B2: LSD 5% = 42.27 kg/ha; LSD 1% = 57.76 kg/ha; LSD 0.1% = 77.41 kg/ha.

Statistical analysis of the results showed that the Orion and Flamenco varieties of the experimental study in which the main tillage was plowing, recorded the highest yields being found distinctly significant with values located in the difference class "a" with 1654.0 and 1636.0 kg/ha, respectively (Table 2).

Table 2. Analysis of the influence of tillage and cultivated variety on yield of chickpea crop, multiple comparisons, average of research years 2023-2024

Position no.	Variant	Yield (kg/ha)	Value group
I	Plowing/Orion (a1b4)	1654.0	a
II	Plowing/Flamenco (a1b3)	1636.0	a
III	Plowing/Burnas (a1b1)	1501.5	b
IV	Plowing/Rodin (a1b2)	1472.5	b
V	Chisel/Orion (a2b4)	1376.0	c
VI	Chisel/Flamenco (a2b3)	1357.5	c
VII	Chisel/Rodin (a2b2)	1276.0	d
VIII	Chisel/Burnas (a2b1)	1267.5	d
IX	Disc harrow/Flamenco (a3b3)	804.0	e
X	Disc harrow/Orion (a3b4)	788.5	e
XI	Disc harrow/Rodin (a3b2)	723.0	f
XII	Disc harrow/Burnas (a3b1)	722.5	f

Factor A1/B2: LSD 5% = 42.27 kg/ha; LSD 1% = 57.76 kg/ha; LSD 0.1% = 77.41 kg/ha.

The influence of cultivated variety and tillage on productivity parameters in chickpea crop for the average of the research years 2023-2024, such as number of main shoots/plant, total number of

pods/plant of which fertile and sterile, number of kernels/plant, number of kernels/pod and weight of kernels/plant are presented in Table 3. The mean number of main shoots/plant had the highest values in the plow tillage being on average 4.00, followed by chisel with mean value of 3.65 and the least developed plants were in the disc harrowed plot variety with mean values of 2.70. In terms of varieties influence, Orion exceeded the other varieties with mean values of 3.93, followed by Flamenco with 3.57, Rodin with 3.15 and Burnas with 3.07.

The average number of pods/plant was influenced more by the tillage than by the variety sown. The average number of pods/plant was 17.95 pods/plant in the plowing tillage, of which 2.35 were sterile pods, with a percentage of 13.09%, similar to the chisel tillage but lower than the disc harrowing tillage. In chisel plot, the number of pods per plant decreased to 16.95 and the number of sterile pods increased to 2.25 with a percentage of 13.27%. Thus, the lowest number of pods/plant was recorded in the disc harrow, on average 10.60 of which 2.60 sterile pods with a 24.53%. In terms of varieties, Orion had the lowest number of pods/plant of 13.82 but also the lowest number of sterile pods of 2.00. It was compared to Flamenco, which had 14.55 pods/plant of which 2.27 sterile pods, followed by Rodin with 15.99 pods per plant of which 2.58 sterile pods and then Burnas with 16.22 pods/plant of which 2.68 sterile pods.

The average number of kernels/plant was influenced more by the tillage than by the chickpea variety. In plow tillage, it was 19.80 kernels/plant, in chisel tillage it was 18.20 kernels/plant and in disc harrow tillage it was very low at 10.55 kernels/plant. The influence of the variety on the number of kernels/plant highlights the varieties Rodin and Burnas with 17.35 and 17.13, followed then by Flamenco with 15.42 and least in Orion with 14.78. Due to the characteristics of Orion and Flamenco varieties to have large kernel size, it resulted in better yield compared to Burnas and Rodin varieties which have much smaller kernel size.

Table 3. Influence of cultivated variety and tillage on chickpea productivity parameters, average of research years 2023-2024

No. crt.	Tillage	Variety	No. main shoots	No. pods/plant			No. kernels/ plant	No. kernels/ pod	Weight kernels/ plant (g)
				Total	Fertile	Sterile			
1	PLOWING	Burnas	3.65	19.35	16.35	3.00	21.35	1.11	5.05
2		Rodin	3.65	18.95	16.30	2.65	21.30	1.14	4.95
3		Flamenco	4.05	17.40	15.55	1.85	18.85	1.09	5.45
4		Orion	4.60	15.95	14.10	1.85	17.65	1.11	5.55
Plowing average			**4.00**	**17.95**	**15.55**	**2.35**	**19.80**	**1.11**	**5.25**
5	CHISEL	Burnas	3.25	18.15	15.55	2.60	19.10	1.05	4.55
6		Rodin	3.35	18.15	15.55	2.60	19.70	1.09	4.60
7		Flamenco	3.75	16.05	14.05	2.00	17,25	1.08	4.85
8		Orion	4.05	15.30	13.55	1.75	16.80	1.10	4.75
Chisel average			**3.65**	**16.95**	**14.65**	**2.25**	**18.20**	**1.08**	**4.70**
9	DISC HARROW	Burnas	2.30	11.15	8.70	2.45	10.95	0.98	2.55
10		Rodin	2.45	10.85	8.35	2.50	11.05	1.02	2.60
11		Flamenco	2.90	10.15	7.20	2.95	10.15	1.00	2.85
12		Orion	3.15	10.20	7.80	2.40	9.90	0.97	2.95
Disc harrow average			**2.70**	**10.60**	**8.00**	**2.60**	**10.55**	**0.99**	**2.75**
Varieties average		**Burnas**	**3.07**	**16.22**	**13.53**	**2.68**	**17.13**	**1.05**	**4.05**
		Rodin	**3.15**	**15.99**	**13.40**	**2.58**	**17.35**	**1.08**	**4.05**
		Flamenco	**3.57**	**14.55**	**12.27**	**2.27**	**15.42**	**1.06**	**4.38**
		Orion	**3.93**	**13.82**	**11.82**	**2.00**	**14.78**	**1.06**	**4.42**

The average number of kernels in the pod for plowing and chiseling was 1.11 and 1.08 respectively and for disk harrowing 0.99. The influence of varieties on the average number of kernels in the pod is irrelevant, with very small differences. The kernels weight per plant was influenced more by tillage but also by the variety used. Plow tillage showed average values of 5.25 g, followed by chisel tillage of 4.70 g and disk harrow tillage of 2.75 g. The influence of

the varieties on the mass of kernels per plant leads to the highlighting of Orion and Flamenco varieties with 4.42 g and 4.38 g respectively. The varieties Burnas and Rodin had less than 4.05 g kernels weight per plant.

The influence of cultivated variety and tillage on the quality parameters in chickpea crop for the average of the research years 2023-2024, such as Thousand Kernel Weight (TKW), hectoliter mass (HM), protein and lipid content in kernels of chickpea crop are presented in Table 4.

Thousand Kernel Weight (TKW) registered the highest mean value in the plow tillage of 280.75 g, followed by the chisel tillage of 272.25 g and 263.90 g in the disc tillage, and the values differed widely among the varieties. In Orion the TKW was the highest at 324.12 g, thus justifying the higher yield production compared to Burnas which had the lowest TKW among the analyzed varieties of 239.95 g. The variety Flamenco succeeded after Orion with a TKW of 283.12 g and the variety Rodin with a low TKW of 241.93 g.

The average hectolitric mass (HM) was 74.40 kg and 74.65 kg, respectively for the plowing and discing tillage and 75.05 kg for the chiseling tillage. In terms of varieties, the average value was very low for Orion of 72.93 kg, for Flamenco it was 74.60 kg and for Rodin and Burnas the values were similar at 75.50 and 75.78 kg, respectively.

Kernel protein content was influenced by the tillage but also by the variety used. The average value was 24.72% in plow tillage, 24.35% in chisel tillage and significantly lower in disc harrow tillage of 23.28%. Among the varieties used, the Orion variety disclosed negatively with a low protein content of 23.21% in the kernels compared to the other varieties which had similar values of 24.23% for Burnas, 24.43% for Rodin and 24.59% for Flamenco.

The lipid content of the grains had similar values between the variants of 6.26% in the plow tillage, 6.24% in the chisel tillage and 6.18% in the disc harrow tillage and between the cultivated varieties ranged between 6.10% and 6.34%.

Table 4. Influence of cultivated variety and tillage on quality indicators in chickpea crop, average of research years 2023-2024

No. crt.	Tillage	Variety	TKW (g)	HM (kg)	Protein (%)	Lipid (%)
1	PLOWING	Burnas	245.30	75.95	25.21	6.54
2		Rodin	248.90	75.50	24.79	6.18
3		Flamenco	292.00	73.75	25.74	6.19
4		Orion	336.80	72.45	23,13	6.11
Plowing average			**280.75**	**74.40**	**24.72**	**6.26**
5	CHISEL	Burnas	241.50	76.00	23.79	6.23
6		Rodin	240.20	75.85	25.10	6.03
7		Flamenco	285.90	75.05	24.92	6.49
8		Orion	321.30	73.35	23.60	6.19
Chisel average			**272.25**	**75.05**	**24.35**	**6.24**
9	DISC HARROW	Burnas	233.05	75.40	23.70	6.25
10		Rodin	236.70	75.15	23.40	6.08
11		Flamenco	271.45	75.00	23.11	6.26
12		Orion	314.25	73.00	22.90	6.14
Disc harrow average			**263.90**	**74.65**	**23.28**	**6.18**
Varieties average		**Burnas**	**239.95**	**75.78**	**24.23**	**6.34**
		Rodin	**241.93**	**75.50**	**24.43**	**6.10**
		Flamenco	**283.12**	**74.60**	**24.59**	**6.31**
		Orion	**324.12**	**72.93**	**23.21**	**6.15**

CONCLUSIONS

The research conducted on the reddish preluviosolic soil type at Moara Domneasca has shown that for the chickpea crop, the varieties cultivated and the basic tillage are important elements for improving yield and quality parameters.

The obtained results clearly revealed differences between the chickpea varieties studied (Burnas, Rodin, Flameco and Orion), but especially between the tillage methods (plow at 25 cm

depth, chisel at 35 cm depth and disc harrow at 12 cm depth).

The highest yield was acquired by Orion variety in the experimental trial in which the basic work was the plowing tillage while the Flamenco variety had the highest protein and lipid content. Although the chickpea crop is tolerant to drought, due to the lack of rainfall unevenly distributed during the 2 years of trials as well as extremely high temperatures, the yield was low because of water deficiency.

The research results show that the chickpea yield varied greatly in terms of tillage and less in terms of cultivated varieties. The average yield of cultivated varieties for the variant using plowing tillage was 1566.0 kg/ha, a satisfactory yield considering the drought recorded during the trial.

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