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Research Article
(Araştırma Makalesi)

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Effects of conventional and ridge planting methods at different plant densities on yield and yield components in chickpea

Nohutta farklı bitki sıklıklarında konvansiyonel ve sırta ekim yönteminin verim ve verim bileşenleri üzerine etkisi

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ABSTRACT

Objective: This study was carried out to determine the applicability of the ridge sowing method and the appropriate sowing density for chickpeas on existing ridges after cotton under rain-dependent conditions.

Material and Methods: The trials were carried out at split randomized block design with three replications. Two planting methods (ridge planting and conventional planting), and five planting density (30, 35, 40, 45 and 50 seed per square meter) were discussed as application issues.

Results: It was determined that ridge planting method was better than conventional planting method in terms of investigated characters as days to 50% flowering, days to maturity, plant height, first pod height, primary branches plant-1 and anthracnose disease value in the study. It was seen that seed yields were affected less from environmental climate changes for ridge planting method, and anthracnose disease value occurred at lower ratio compared to conventional planting. It was determined that the convenient planting density of chickpea was 40 seed per square meter for conventional planting and 45 seed for ridge planting in the economic analysis.

Conclusion: The average yield of the conventional planting method after cotton using the appropriate planting density (2081.7 kg ha^{-1}) was found to be 6.2% higher than the yield of the ridge planting method (1960.0 kg ha^{-1}). However, in the economic analysis, it was determined that ridge planting was 9.2% more profitable than the conventional planting method in terms of net income.

ÖZ

Amaç: Bu çalışma yağışa dayalı koşullarda pamuk sonrası mevcut sırtlara nohutta doğrudan ekim yönteminin uygulanabilirliği ve uygun ekim sıklığının belirlenmesi amacıyla ürütülmüştür,

Materyal ve Metot: Tarla denemeleri tesadüf bloklarında bölünmüş deneme desenine göre üç tekerrürlü olarak kurulmuştur. Uygulama konuları olarak iki ekim yöntemi (sırta ve konvansiyonel ekim) ve beş ekim sıklığı (metrekareye 30, 35, 40, 45 ve 50 tohum) ele alınmıştır.

Bulgular: Araştırmada %50 çiçeklenmeye kadar geçen gün sayısı, olgunlaşma gün sayısı, bitki boyu, ilk bakla yüksekliği, bitkide ana dal sayısı ve antraknoz hastalık değeri açısından sırta direk ekim yönteminin geleneksel ekim yöntemine göre daha iyi olduğu belirlenmiştir. Doğrudan sırta ekim yönteminde tohum veriminin çevresel iklim değişikliklerinden daha az etkilendiği ve geleneksel ekime göre antraknoz hastalık çıkışının daha düşük oranda oluştuğu görülmüştür. Yapılan ekonomik analizde geleneksel ekim için metrekareye 40 tohum yeterli olurken, doğrudan sırta ekimde 45 tohumun yeterli olduğu ortaya konulmuştur.

Sonuç: Sonuç olarak, nohutta uygun ekim sıklığı kullanılarak pamuk sonrası geleneksel ekim yöntemin ortalama verimi (2081.7 kg ha^{-1}) sırta ekim yöntemi veriminden (1960.0 kg ha^{-1}) %6.2 daha yüksek bulunurken, yapılan ekonomik analizde net kazanç bakımından ise sırta ekiminin geleneksel ekim yöntemine göre %9,2 daha karlı olduğu belirlenmiştir.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the first plants that are cultivated in the world. Gene center is East Mediterranean Region which Türkiye also has taken part in (Akçin, 1988). Chickpea is ranked at second after bean among legumes that are produced in the world, and also ranked as the second with 480.000-ton production in Türkiye (FAOSTAT, 2022). Chickpea has a significant role for human nutrition because chickpea seeds include high protein ratio (15-32%), and high carbohydrate ratio (50-74%), and are rich in terms of P, Ca, Fe minerals, and vitamins such as A, B, and niacin (Jukanti et al., 2012). Besides, chickpea's value increases in more and more nowadays because it has a character that it can fix air's free nitrogen such as other legumes, and it increases the significance of environmental and sustainable agriculture.

Besides using natural sources as effective and efficient, applying techniques which can help to develop people who produce in terms of socio-economically, are obligatory for the sustainability of agricultural production. Southeastern Anatolia Region is a region where has a high production potential, various products can be cultivated in terms of ecological conditions. In the region, cotton-legumes (lentil and chickpea) or corn-legumes rotation system have appeared gradually instead of wheat-cotton, and wheat-corn rotation system at irrigable fields in terms of protecting agricultural soils and natural balance. Harvesting of cotton and corn cultivated as a second crop in the region, and falling rain at autumn early, or region's climate continues to be arid can hinder preparation of convenient seed bed for lentil and winter chickpea and planting timely for some years. Because of that, reduced tillage and applying ridge planting methods has become prominence for crops that have taken at planting alternation day by day.

According to the conducted study results, when production systems were compared yield obtained from ridge planting remained at the same rate or increased a little with respect to conventional tillage (Aykas et al., 2010). As a result of this, production costs are saved up largely for ridge planting (Yalçın et al., 1997). Besides, soil erosion decreases, water loses occurred from soil surface with evaporation decrease, and soil characteristics improve (Yuan at al., 2009). In Türkiye, studies related with ridge planting applications have been carried out for ten years. Generally, these studies are related with irrigated farming. There are not enough ridge planting studies related with dry farming and legume cultivation. In contrast to traditional agriculture, ridge planting method is a method of planting seeds directly into uncultivated soil with special teams and equipment, leaving the post-harvest residues of other plants as cover in the field without cultivating the soil. Thanks to this method, the risk of erosion is reduced, the soil does not lose moisture, time saving increases and carbon emissions are reduced. Thus it is a sustainable agriculture method. Planting density, as in other plant species, is one of the important environmental factors affecting the yield potential in chickpea. For this reason, the most suitable planting density should be determined in order to obtain maximum yield in different planting methods.

This study aimed to determine the applicable of ridge planting method for chickpea and the most convenient planting norm for ridge planting at chickpea planting rotation after cotton under Southeastern Anatolian Region.

MATERIALS and METHODS

Experiment conditions

The field experiments were conducted during 3 consecutive growing seasons (2010–2011, 2011–2012 and 2012–2013) at the GAP International Agricultural Research and Training Center, Diyarbakır under natural rainfall conditions. The soil of experiment field is clayed-loamy, medium-saline in terms of total saline value (0.400%), its organic substance is little (1.66), it has strong alkaline (Ph:8.07) in terms of soil reaction, is calcareous at medium level (7.93%), has little phosphor (33.8 kg ha^{-1}) that is efficient and can be used from the plant. Diyarbakır where the experiment was conducted has continental climate. It is quite hot and dry in summer and cold, little rainy in winter. While the temperature averages of Diyarbakır

for chickpea vegetation period were 13.9, 14.9 and 20.0°C, rainfall were 550.6, 405.1 and 680.6 mm respectively in the experiment years (Table 1).

Experimental Design

Diyar 95 chickpea variety was used as a material. The field trial was carried out at split randomized block design with three replications. Two planting methods (ridge planting and conventional planting) and five different planting density (30, 35, 40, 45 and 50 seed m^{-2}) were tested as application issues. Planting method was placed in main plots, planting densities were placed in sub-plots. For ridge planting; after cotton harvest, cotton straws were cut up with stalk cutter and two rows (inter-row was 15 cm) were cultivated with modified sowing machine at the top of the ridges which were grown cotton at present 70 cm range. For conventional planting; after cotton was harvested, and soil was cultivated with plough + cultivator + dredge cultivation was applied in 8 cm depth with plot sowing machine and interrow was 30 cm. Sowings were made at the first week of November for all three years. Average 40 kg N and 60 kg P_2O_5 used per hectare with sowing in the study. Experiments' harvest was applied with experiment plot combine harvester at the last week of June. In the study, days to 50% flowering, days to maturity, plant height, first pod height, primary branches $plant^{-1}$, pods $plant^{-1}$, seeds $plant^{-1}$, 100 seed weight, seed yield, anthracnose disease value observations were taken.

Table 1. Climatic data of research area (Anonymous, 2013)

Çizelge 1. *Araştırma yerine ilişkin iklim verileri (Anonymous, 2013)*

Meteorological parameters	Year	Months								
		October	November	December	January	February	March	April	May	June
Mean temperature (°C)	2010/11	26.9	18.1	11.2	6.6	3.5	4.7	9.0	12.9	17.6
	2011/12	25.0	16.4	6.4	2.3	2.4	2.0	5.2	15.2	19.6
	2012/13	26.1	18.5	12.0	5.1	2.7	6.1	9.5	14.5	19.0
	LT	24.9	17.2	8.9	3.7	1.6	3.5	8.3	13.7	19.1
Total rainfall (mm)	2010/11	0.4	63.0	0.0	48.0	40.0	49.9	46.6	209.0	80.1
	2011/12	9.2	11.8	73.0	40.2	78.3	74.4	44.0	26.2	41.0
	2012/13	1.8	107.4	83.2	160.8	82.2	85.2	19.8	39.4	98.0
	LT	4.2	33.6	54.1	72.1	64.0	72.7	69.5	62.8	40.1
The average relative humidity (%)	2010/11	27.7	56.1	40.5	68.5	73.1	69.1	56.1	75.6	67.8
	2011/12	30.4	41.5	58.5	73.9	84.5	68.2	58.6	58.4	58.2
	2012/13	23.3	55.1	77.3	85.4	83.8	82.3	62.7	63.6	61.7
	LT	31.0	48.0	68.0	77.0	77.0	73.0	66.0	63.0	56.0

LT: long term (1991-2020).

Statistical analysis

Bartlett's χ2 test was used to verify homogeneity of error variance in the combined analysis. Since the variances of the three years' data were homogeneous, a combined analysis was performed on the data. The results obtained from the study, which was conducted with three replications according to the split parcel experimental design in randomized blocks, were subjected to analysis of variance with the JMP 13.2.0 statistical package, and groupings between the subjects were made according to the LSD test (Little & Hills, 1978; Yurtsever, 1984; Düzgüneş et al., 1987).

RESULTS and DISCUSSION

Days to 50% flowering and maturity

In the variance analysis that was applied for days to maturity, and days to 50% flowering, while planting method, planting density, and year factor were found significant as $P<0.01$ for both characteristics,

and year*planting interaction was found significant as P<0.01 for only days to maturity, other interactions effects were found non-significant (Table 2). Year was found as significant statistically in terms of days to maturity and flowering time. The average values of planting method, planting density, and year*planting method interaction were grouped as at 1% level and they were given at Table 3.

Table 2. ANOVA results of yield and yield components of chickpea grown under different planting methods and planting densities

Çizelge 2. *Farklı ekim yöntemi ve ekim sıklıklarında yetiştirilen nohutta verim ve verim komponentlerine ait varyans analiz sonuçları*

Source of Variance	DF	Mean Square (MS)								
		FN	DM	PH	FPH	BN	PN	SN	100- SW	SY
Y	2	2869.2**	219.5**	104.3**	121.6**	0.44**	274.2**	231.8**	141.24**	26446.6**
R (Y)	6	0.17	0.61	9.24	2.7	0.01	11.6	8.43	1.69	219.7
M	1	102.4**	96.1**	872.2**	892.4**	0.45**	28.2*	26.2*	0.82ns	3317.5**
Y × M	2	0.10ns	0.6**	84.07*	134.1*	0.13*	475.5**	504.4**	0.34ns	27948.1**
Eror1	6	0.17	0.06	12.11	2.97	0.02	2.26	2.79	0.17	147.1
D	4	3.2**	3.1**	4.51ns	0.61ns	0.04ns	27.2**	18.09**	0.25ns	4497.6**
Y × D	8	0.70 ns	0.64 ns	5.92 ns	4.04 ns	0.01 ns	1.5 ns	1.98 ns	0.51 ns	215.2 ns
M × D	4	0.18 ns	0.13 ns	2.51 ns	3.21 ns	0.01 ns	1.5 ns	6.41 ns	0.08 ns	286.5 ns
Y × M × D	8	0.09 ns	0.16 ns	4.00 ns	2.13 ns	0.01 ns	0.99 ns	3.25 ns	0.10 ns	94.0 ns
Error 2	48	0.38	0.49	6.27	2.31	0.19	2.1	2.89	0.32	184.3
General	89									
CV (%)		1.1	1.0	4.1	4.7	4.9	5.4	5.9	1.4	6.7

*: 0.05, **: 0.01 Significant; ns: non-significant

Y: Year; M: Planting methods; D: Plant Density; Y × M: Year and Planting Method interaction; Y × D: Year and Plant Density interaction; M × D: Planting method × Plant Density interaction; Y × M × D: Year, Planting method and Plant Density interaction DF: Degree of freedom; CV: Coefficient of variation; FN: days to 50% flowering; DM: days to maturity; PH: Plant height (cm); FPH: first pod height (cm); BN: primary branches plant^{-1}; PN: pods plant^{-1}; SN: seeds plant^{-1}; 100-SW: 100 seed weight; SY: seed yield ha^{-1}.

When Table 3 was examined the shortest flowering (112.3 days) was found in 2012 by years, the shortest days to maturity (180.8 days) was found in 2013, the longest flowering (131.8 days) and days to maturity (185.8 days) were found in 2011. The shortest flowering (120.5 days) and days to maturity (181.7 days) were obtained for ridge planting method. It was thought that the earliness of ridge planting method stemmed from earlier planting appearance, airing better plant's root zone at rainy periods and fast plant developing. Average days to maturity changed between 179.6 and 186.9 days for year*planting method interaction which was found significant statistically in terms of days to maturity. While the earliest days to maturity was determined for ridge planting method in 2013 as 179.6 days, the latest days to maturity was determined for conventional planting method in 2011 as 186.9 days. It was thought that this difference between days to maturity resulted from temperature and moisture ratios on May and June in the years in which the study was conducted. Van Der Maesen (1972) reported that air humidity has an effect on chickpea's flowering, and flowering late at the high ratio of moisture. It was seen that average days to 50% flowering changed between 120.1 and 122.1 days, days to maturity changed between 182.1 and 183.2 days. As plant number increases per square meter, days to maturity and days to 50% flowering increase too. The highest values for both characteristics were determined for 45 seed m^{-2} planting density, the lowest ratios were determined for 30 seed m^{-2} planting density. Similar to our findings some researchers reported that when plant number increases per square meter, maturation and flowering increase too (Pramanik et al., 1990; Yiğitoğlu, 2006).

Table 3. Effect of different planting method and planting density on agronomic parameters of chickpea

Çizelge 3. *Farklı ekim yöntemi ve ekim sıklığının nohutun agronomik parametrelerine etkisi*

Factor	Characteristics			
Year (Y)	**FN**	**DM**	**PH**	**FPH**
2011	131.8±0.21[a]	185.8±0.19[a]	59.6±1.08[b]	34.0±1.09[a]
2012	112.3±0.25[c]	181.6±0.26[b]	59.0±0.56[b]	29.9±0.46[c]
2013	120.7±4.53[b]	180.8±4.53[c]	62.5±0.56[a]	31.8 ±0.40[b]
Planting method (PM)				
Conventional Planting (CP)	122.7±1.21[a]	183.7±0.35[a]	57.2±0.50[b]	28.7 ±0.26[b]
Ridge planting (RP)	120.5±1.20[b]	181.7±0.34[b]	63.5±0.45[a]	35.9 ±0.54[a]
Plant Densities (D)				
30 seed m^{-2}	121.0±1.90[c]	182.1±0.57[c]	60.6±1.05	32.0±0.86
35 seed m^{-2}	121.6±1.92[b]	182.7±0.57[b]	60.6±1.08	32.2±1.08
40 seed m^{-2}	121.5±1.99[b]	182.7±0.65[b]	60.9±1.06	31.9±1.05
45 seed m^{-2}	122.1±1.95[a]	183.2±0.57[a]	60.3±1.08	32.0±1.01
50 seed m^{-2}	121.8±2.00a[b]	182.8±0.66a[b]	59.6±1.08	31.7±1.09
Year * Planting method				
2011 * CP	132.9±0.18	186.9±0.18[a]	54.6±0.64[c]	28.4 ±0.44[d]
2012 * CP	113.3±0.15	182.4±0.15[c]	56.5±0.93[c]	27.7 ±0.56[d]
2013 * CP	121.9±0.12	181.9±0.16[d]	60.6±0.52[b]	30.2 ±0.20[c]
2011 * RP	130.7±0.15	184.7±0.15[b]	64.6±0.39[a]	39.5 ±0.33[a]
2012 * RP	111.3±0.21	180.7±0.22[e]	61.5±0.56[ab]	32.2 ±0.43[b]
2013 * RP	119.7±0.21	179.6±0.25[f]	64.3±0.70[a]	33.4 ±0.36[b]

[a,b,c] Values within a column with different superscripts differ significantly at P<0.01, ; FN: days to 50% flowering; DM: days to maturity; PH: Plant height (cm); FPH: first pod height (cm); BN: primary branches $plant^{-1}$.

Plant height and first pod height

In the variance analysis applied for plant height and first pod height values, year and planting method were found significant at p<0.01 for both characteristics. But year*planting method interaction was effective at p<0.05 significance level, planting density and other interactions were not statistically significant (Table 2). Planting method that was found significant and the average values and comparisons of year and year*planting method interaction and planting densities were given at Table 3.

While the highest plant height (62.5 cm) was determined in 2013 year, the highest pod height (34.0) was determined in 2011 regarding years which were found statistically significant and grouped the discrepancies. When planting methods were compared in terms of plant height and first pod height, the highest plant height (63.5 cm) and first pod height (35.9 cm) was determined for ridge planting method. In 2011, the year*planting method interaction was determined. It was found that plant height affected less from changing climate factor for the ridge planting method, and average plant heights for ridge planting method for both three years were at the same group statistically (Table 5). Tisdall and Hodgson (1990) reported that ridge surfaces were provided a good airing, and because of that they did not prevent plant development.

Pod and seed number per plant

The variance analysis results which were applied on pod and seed number values per plant showing the effect of ridge planting method on chickpea seed yield are given in Table 2. The year, plant density and year*planting method interaction were found significant at P<0.01 and plant method was found significant at P<0.05. However, plant density and other interactions were found non-significant for two characteristics. The highest number of pods and seeds per plant were determined in 2012 year, and the lowest values were found in 2011year in terms of years. Pod and seed number per plant obtained

from conventional planting method (27.5 pod and 29.2 seed) were higher than ridge planting method (26.4 pod and 28.1 seed) in terms of planting methods. Pod number per plant changed between 20.1 - 33.6 pods, seed number changed between 21.9 and 35.4 seeds for year*planting method interaction which was found statistically significant.

The highest values were found for conventional planting method in 2012, the lowest values were found conventional planting method in 2011 for two characteristics (Table 4). Hence, it was seen that chickpea's pod and seed number per plant were affected less from changing climate factors.

Table 4. Main effects of sowing method and sowing density on agricultural characteristics of chickpeas

Çizelge 4. *Nohutta ekim yöntemi ve ekim sıklığının tarımsal özellikler üzerindeki ana etkileri*

Factor	**Characteristics**				
Year (Y)	**BN**	**PN**	**SN**	**100-SW**	**SY**
2011	2.9 ±0.01^{a}	23.5 ±0.74^{b}	25.5 ±0.78^{c}	40.8±0.15^{b}	1691.6±68.01^{c}
2012	2.8 ±0.03^{b}	29.1 ±0.88^{a}	30.8 ±0.90^{a}	37.4±0.08^{c}	2267.5±45.35^{a}
2013	2.7 ±0.09^{c}	28.3 ±0.09^{a}	29.7 ±0.09^{b}	41.4±0.09^{a}	2103.2±4.535^{b}
Planting method (PM)					
Conventional Planting (CP)	2.8 ±0.02^{b}	27.5 ±0.90^{a}	29.2 ±0.90^{a}	40.0±0.27	2081.7±79.53^{a}
Ridge planting (RP)	2.9 ±0.02^{a}	26.4 ±0.31^{b}	28.1 ±0.32^{b}	39.8±0.28	1960.0±28.60^{b}
Plant Densities (D)					
30 seed m^{-2}	2.9±0.04	28.5 ±1.23^{a}	29.7 ±1.20^{a}	39.8±0.47	1829.7±82.43^{c}
35 seed m^{-2}	2.9±0.04	27.5 ±1.10^{ab}	29.3 ±1.12^{ab}	39.9±0.45	1880.4±83.53^{c}
40 seed m^{-2}	2.9±0.03	27.3 ±1.06^{bc}	28.9 ±1.08^{ab}	39.9±0.48	2143.0±91.02^{ab}
45 seed m^{-2}	2.8±0.04	26.3 ±0.94^{c}	28.3 ±0.99^{b}	40.0±0.43	2183.2±96.49^{a}
50 seed m^{-2}	2.8±0.04	25.3 ±0.95^{d}	27.1 ±0.94^{c}	39.8±0.41	2067.6±100.2^{b}
Year * Planting Method					
2011 * CP	2.9±0.02^{a}	20.1 ±0.61^{e}	21.9 ±0.61^{d}	40.8±0.19	1416.2±44.36^{d}
2012 * CP	2.7±0.02^{bc}	33.6 ±0.48^{a}	35.4 ±0.54^{a}	37.6±0.23	2589.3±57.48^{a}
2013 * CP	2.6±0.03^{c}	28.9 ±0.50^{b}	30.3 ±0.56^{b}	41.6±0.11	2238.0±49.44^{b}
2011 * RP	2.9±0.04^{a}	27.0 ±0.30^{c}	29.1 ±0.31^{b}	40.8±0.12	1966.5±43.86^{c}
2012 * RP	2.9±0.03^{a}	24.6 ±0.54^{d}	26.2 ±0.58^{c}	37.3±0.12	1946.8±58.68^{c}
2013 * RP	2.7±0.03^{b}	27.6±0.52^{bc}	29.0 ±0.46^{b}	41.3±0.12	1968.4±49.66^{c}

^{a,b,c} Values within a column with different superscripts differ significantly at P<0.01, BN: primary branches plant^{-1}; PN: pods plant^{-1}; SN: seeds plant^{-1}; 100-SW: 100 seed weight; SY: seed yield ha^{-1}.

In terms of total pod and seed number; 30 plant m^{-2} of plant density gave the highest values (28.5 pod and 29.7 seed) and followed by 35 seed m^{-2} of plant density, whereas the lowest value was obtained from 50 seed m^{-2} of plant density. It was observed that when plant density increased, branching per plant decreased, and therefore pods and seed number per plant decreased. Some researchers also reported that when plant number increased per square meter, pod number per plant decreased (Akdağ, 1985; Brandon et al., 1998; Regan et al., 1999; Liu & Gan, 2001).

Seed yield

In the variance analysis which was arranged for seed yield values at unit area; year, planting method, planting density and year*planting method interaction effects on seed yield were found statistically significant (p<0.01). But the other interactions between factors (Y*D, M*D, Y*M*D) were found non-significant (Table 2). The highest seed yield (2267.5 kg ha^{-1}) was obtained in 2012 when total rainfall ratio was the lowest, but the distribution of precipitation was more regular. The lowest yield (1691.6 kg ha^{-1}) was obtained in 2011 when the distribution of precipitation was irregular (Tables 1 & 4). This case showed that the distribution of

precipitation which dropped at plant vegetation period on seed yield was more effective than total rainfall ratio (Aykut Tonk at al., 2011). Planting methods were compared in terms of seed yield at unit area; it was determined that conventional planting method (2081.7 kg ha^{-1}) was higher than ridge planting method (1960.0 kg ha^{-1}). In the study while the highest seed yield (2589.3 kg ha^{-1}) was obtained from conventional planting method in 2012, the lowest seed yield (1416.2 kg ha^{-1}) was obtained from conventional planting method in 2011 for year*planting method interaction that was found statistically significant.

While there were significant changes in climate parameters such as humidity, temperature and total rainfall during the chickpea growing season in which the study was conducted, the difference between the yields of the ridge planting method was not statistically significant and they were in the same group. However, the difference between the yields in the conventional planting method was significant and they were statistically in different groups. Thus, it can be said that the ridge planting method is less affected by changing climate factors than the conventional planting method (Table 4). Similar results reported by Roy et al. (2014) that chickpea sown without seed bed preparation with Pantnagar zero till drill produced the highest seed yield followed by zero tillage after removal of stubble. Stringi et al. (2004) compared the performance of chickpea under no tillage, mulch tillage and conventional tillage and found that average grain yield was significantly higher under no tillage than conventional tillage. But no significant differences were recorded between mulch tillage and conventional tillage.

Combined data presented in Table 4 showed that, seed yield was affected by plant densities. The highest seed yield (2183.2 kg ha^{-1}) was obtained from 45 seed m^{-2} for the average of two planting methods in terms of planting density and followed by 40 seed m^{-2}. Whereas the lowest value was obtained from 30 seed m^{-2}. In the combined of the three years, it was determined that 40 seed m^{-2} was convenient for conventional planting method and 45 seed m^{-2} for ridge planting method.

100 seed weight

According to Table 2, results of statistical analysis indicated that, year had a significant effect on 100 seed weight, but effects of planting method, planting density and interaction were not found significant. The highest 100 seed weight (41.4 g) was found in 2013 when May was rainy and the distribution of precipitation was more regular, the lowest value (37.4 g) was found in 2012 in terms of years. It was thought that the rainfall was low on April and May when chickpeas were in chickpea's flowering, and pod setting periods in the region in 2012, short time arid stress stemmed from high temperature values had a negative effect on 100 seed weight. Similar to our findings, some researchers also reported that chickpea's 100 seed weight changed depending on changes occurred environmental factors (Bozoğlu, 1995; Akdağ, 2001; Türk & Sağır, 2001; Düzdemir et al., 2007).

Anthracnosis disease (*Ascochyta rabiei*)

Disease assessment was based on the 1-9 rating scale which was modified for seedling bioassays from Reddy & Singh (1984). The average value of anthracnose disease *(Ascochyta rabiei*) at different planting densities for chickpea' s conventional and ridge planting method were given at Table 5.

When examining Table 5, it was seen that year and planting method had an effect on anthracnosis disease for chickpea, but planting density did not have any effect. The highest disease value was seen in 2011 when spring rainfall and moisture ratio were high for both planting methods in terms of years. Disease values for ridge planting method was lower than conventional planting method disease values at all three years in terms of planting methods. Similar result was reported by Kanouni *et al*. (2011) who reported environmental conditions have important effect on the lifecycle of *A. rabiei*, the infection process and disease development. In terms of anthracnose disease, ridge planting method was quite advantageous than conventional cultivation method in years with high rainfall and humidity for the winter chickpea sowing.

Table 5. Anthracnosis (*Ascochyta rabiei*) values (1…9 rating scale)) of chickpea grown under different planting method and planting density

Çizelge 5. *Nohuttun farklı ekim yöntemi ve ekim sıklıklarındaki antraknoz hastalık değerleri (1…9skalası)*

Planting Method	Planting Densities	Years		
		2011	2012	2013
Conventional Planting	30 seed m^{-2}	5	3	3
	35 seed m^{-2}	5	3	3
	40 seed m^{-2}	5	3	3
	45 seed m^{-2}	5	3	3
	50 seed m^{-2}	5	3	3
Ridge Planting	30 seed m^{-2}	3	1	1
	35 seed m^{-2}	3	1	1
	40 seed m^{-2}	3	1	1
	45 seed m^{-2}	3	1	1
	50 seed m^{-2}	3	1	1

1: healthy plant, no disease; 3: lesions easily seen, but plant is mostly green; 5: lesions girdle stems, most leaves show lesions.

Economic analysis

The yield averages of three years were regarded to compare applied methods economically and partial budgeting method was used (Keklikçi, 1994). The 2013 cultivation period data belong to Provincial Directorate of Food Agriculture and Livestock and Chamber of Agriculture were used for machine hire costs and inputs that were used during the experiments. While expenditures were calculated production area was assumed as it was a property. So, fields hire cost excluded in input costs. As seen input-output costs were given in Table 6. The highest net income for unit area was determined for ridge planting method as 1720 TL ha^{-1}. When methods' output/input ratios were analyzed, the highest value was seen for ridge planting method as 3.17. According to this result; ridge planting method was determined as 9.2% more profitable than conventional planting method. Similar results were also recorded by Banjara et al. (2017). They observed gross return was also higher under minimum tillage and line sowing of seeds after harvesting of rice, but net return and B:C (2.96) ratio were highest under zero tillage direct drilling of seeds. Up to 40% energy saving is achieved in the zero tillage method, which is an application of direct seeding (Aykas et al., 2005).

Table 6. Input output quantity of chickpea grown under different planting methods and planting density (TL ha^{-1})

Çizelge 6. *Faklı ekim yöntemi ve ekim sıklığında yetiştirilen nohuttun girdi ve çıktı miktarları (TL ha^{-1})*

	Conventional planting method	Ridge planting method
Average Yield (kg ha^{-1})	2081.7	1960
Gross Income (TL ha^{-1})	3123	2940
Total Variable costs (TL ha^{-1})	1296	926
Net Income (TL ha^{-1})	1575	1720
Output / input ratios	2.41	3.17

CONCLUSIONS

It was seen that ridge planting method did not give a significant yield difference at base ridges for chickpea's planting alternation after cotton when compared to conventional planting method. However, when economical evaluations were applied between average yields, ridge planting method at present ridges was more economical than conventional planting method for income/expenditure ratios. At alternation (cotton-chickpea, or second crop corn-chickpea) system, preparing seed bed at regions where it is a matter for winter chickpea planting after cotton that leaves the field lately in fall and corn as the

second crop, the most convenient seed bed was left by ridge planting method at base ridges. It was determined that convenient planting density for chickpea was 40 seed per square meter for conventional method, and 45 seed for ridge planting. *Ascochyta rabiei*, the most serious chickpea disease worldwide, was less common in the ridge planting method due to air circulation in the spaces between the ridges. Also ridge planting method decreased water interception damage which occurred because of water accumulation in fields that are heavy textured, and its levelling was out of order, and provided earliness. As a suggestion, the ridge sowing method can be applied by growers for winter chickpea planting in areas where cotton-chickpea rotation is applied, both in terms of planting time and field traffic and because it is more economically suitable.

Data Availability

Data will be made available upon reasonable request.

Author Contributions

Conception and design of the study: İE, MY, MK; sample collection: İE, MY, MK; analysis and interpretation of data: İE, MY, MK; statistical analysis: İE visualization: İE; writing manuscript: İE, MY, MK.

Conflict of Interest

There is no conflict of interest between the authors in this study.

Ethical Statement

We declare that there is no need for an ethics committee for this research.

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