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Effects of Planter Type and Seeding Rate in No-tillage Systems on Wheat Yield in Pol- e Dokhtar

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Abstract

In the cropping year 2013-2014, a split plot experiment using the randomized complete block design with three replications was conducted in a field in Pol-e Dokhtar in Lorestan Province to study the effects of planter type and seeding rates used in direct and customary planting practices. Results showed there were significant differences between planters with respect to percentage of broken seeds at the 1% level. Comparison of the means indicated the highest percentage of broken seeds (5.1%) belonged to the Barzagar-e Hamadani planter and the lowest to the Gaspardo and Sfoggia direct planters. Type of planter also influenced precision in longitudinal distance at the 5% level. Moreover, comparison of the means revealed that the best uniformity in appropriate longitudinal distance between seeds in planted rows was that of the Gaspardo and Sfoggia direct planters and the worst that of the Barzegar-e Hamadani planter and that the effects of various planters were significant at the 5% level. The Gaspardo and Sfoggia direct planters, with 88.26 and 86.49%, respectively, had the maximum uniformity in depth of planting, and the Barzegar-e Hamadani with 79.03% the minimum. ANOVA suggested the various planters were not significantly different in wheat yield, while the effects of seeding rate treatments on wheat seed yield were significant at the 5% level. Nevertheless, comparison of the means showed that the Gaspardo direct planter raised seed yield by 1.32 and 11.13% compared to the Sfoggia direct planter and the Barzegar-e Hamadani planter, respectively, and that it enjoyed relative superiority over them. Moreover, comparison of the means related to seeding rates indicated the 200 kg/ha rate increased seed yield by 11.05 and 24.36%, respectively, compared to the 160 and 240 kg/ha rates. Results of this research suggested direct planting with the Gaspardo planter at the seeding rate of 200 kg/ha achieved maximum seed yield. Therefore, this combination was recommended for the region.

Keywords: seeding rate; direct planting; customary planting; Gaspardo; Sfoggia.

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Introduction

Nowadays, the need for mechanized planting is felt more strongly than ever before. Utilization of advanced planting techniques results in uniform growth and a desirable number of plants per unit area, saves on the quantity of planted seeds, reduces numerous post-planting problems such as competition for available water and soil nutrients and reduction of problems faced in mechanized harvesting, and, finally, increases yield. Use of the moldboard plow and disc together with seed drills is common in tillage and planting operations in Lorestan province, but this practice wastes energy without achieving any tangible increases in yield. Some of the important advantages of conservation tillage are conservation of residues

Remaining from the previous crop, reduced tillage operations, and direct planting on crop residues. Following correct tillage operations, suitable planting methods must be selected. Essentially, various patterns of seed distribution result from the types of planters that are employed. In general, the two main characteristics of the distribution pattern are seed dispersal in the horizontal and vertical planes. Seed distribution in the horizontal plane is usually based on the distance between a specific seed and the seed closest to it. Therefore, if a specified amount of seeds is to be distributed in a given area, this distribution will be optimal when the distance between seeds varies the least. The number of seeds in the unit area, and the manner of horizontal distribution, play a very important role in the optimal use each plant makes of nutrients, water, soil, and sunlight, and in its competition with weeds. Each of these factors can influence yield components in some way. Moreover, uniformity in depth of planting must also be considered because it substantially affects germination percentage.

Purposes of the research

1. Study and comparison of types of planters with respect to their effects on wheat yield and yield components under the climatic conditions in Pol-e Dokhtar

2. Determination of the optimal seeding rate considering the types of planters and wheat yield

Materials and Materials

Geographical location of the experimental site

This experiment was conducted in the southern part of Lorestan Province in Pol-e Dokhtar in the cropping year 2013-2014 in a field where corn was the previous. Climatically, and meteorologically, Lorestan has a four-season climate and various types of weather conditions that clearly vary from the north to the south and from the east to the west.

This research project was carried out in the cropping year 2-13-2014 to study the effects of planter types and seeding rates in direct and customary planting practices. The split plot experiment used the randomized complete block design with three replications as follows:

The first factor was various planting practices using different planters in the major plots at three levels:

1. Direct wheat seed planting using a Gaspardo no-tillage planter (a_1)

2. Direct wheat seed planting employing a Sfoggia no-tillage planter (a_2)

3. Two disking operations performed in perpendicular directions and planting with a Barzagar-e Hamadani planter (a_3)

The second factor was the seeding rate at three levels in the minor plots including:

1. 160 kg/ha (b_1)

2. 200 kg/ha (b_2)

3. 240 kg/ha (b_3)

A field was selected in which corn was previously grown. Using the customary practice, a John Deere 3140 tractor was employed three times using a 24 plate offset disk harrow, and then a Barzegar-e Hamadani seed drill was used to plant the seeds. In no-tillage wheat planting, a Gaspardo Directa 300 and a Sfoggia direct planter (that were made in Italy) were used. The base fertilizers for all the treatments, as recommended by the laboratory based on soil analysis, included 100 kg of urea, 100 kg of concentrated superphosphate, and 100 kg of potassium sulfate per hectare. As is customary in the region, a disk harrow was used to mix the fertilizers with the soil. It must be mentioned that seeds and fertilizers were applied simultaneously by no-tillage direct planters. Nitrogen fertilizer was applied in two stages: before planting as base fertilizer and at tillering before stem elongation as topdressing.The tending operations included irrigation, topdressing, and spraying pesticides. The herbicides used were as follows:

1. The herbicide Logran Extra against broad-leaved weeds at 200g/ha (dissolved in 200 liters of water and sprayed on a hectare of land)

2. The herbicide Topik at 1.3 l/ha (dissolved in 200 liters of water and sprayed on a hectare of land) against narrow-leaved weeds

Sampling for evaluation of various cultural practices and planters

Percentage of broken seeds

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After planter adjustments and calibrations were made, the number of seeds dropped from each furrow opener was separately counted for every planter and the percentage of broken seeds was calculated for each one in three replications using the following relation:

Percentage of broken seeds = [(the total number of seed – the total number of intact seeds)/the total number of seeds] × 100

Depth-of-planting uniformity

After seed germination and stand establishment were complete, about 30 seedlings were randomly selected in each plot and gently pulled out and the distances from the seeds to the spots where the stems were pale (because they did not receive sunlight) were measured with a ruler to determine the depth-of-planting uniformity. The mean of the distances obtained was the depth of planting.

Germination percentage

In each treatment, 5 points were randomly selected in each plot and were marked by placing a metal frame around each one. From the start until the end of seed germination period, the number of seeds that germinated at these points was counted and recorded every day, and percentage germination was calculated using the following relation:

$PE = n/N \times 100$

In the above relation, n is the number of germinated seeds and N the number of planted seeds.

Precision of planters in providing the appropriate longitudinal distance between seeds planted in each row

The lateral distances of plants on planted rows from an imaginary line parallel to them were measured, and the Synaptic formula was used to calculate planter precision:

$Se = (1-y/d) \times 100$

In the above formula, SE is the coefficient of seed distribution uniformity (percentage), d the mean of obtained or adjusted distances between seeds (cm), and y the mean of absolute values obtained from deducting data items from their mean (or the adjusted distance).

Harvesting operations

A measuring metal frame was used to harvest from the ground surface three 1-m^2 samples from each treatment to determine yield components. Each sample was weighed, put in a sack, and used to measure yield components.

Stem height

Thirty plants were randomly selected in each treatment and stem heights from the ground surface to the beginning of the stalks were measured. The mean of the 30 plants was used as the height of the spikes in the related treatment.

Spike length

From each treatment, three samples each containing 10 spikes were randomly selected, their lengths were measured, and the mean length was used as the length of the spike in the related treatment.

Number of spikes per square meter

Using the 1-m^2 measuring frame, three randomly selected samples were cut from the ground surface in each treatment, the number of spikes in each sample was counted, and the mean was used as the number of spikes per square meter.

Number of seeds per spike

Thirty randomly selected samples in each treatment were harvested, the number of seeds in each spike was counted, and the mean was used as the number of seeds per spike in the related treatment.

1000-seed weight

Three 1000- seed samples were taken from each treatment and weighed, and the mean was used as the 1000-seed weight of the related treatment.

Yield and yield components

Three 1-m^2 samples were selected in the middle part of each plot and the plants were harvested to determine seed yield. The harvested plants were weighed and the measured weights were used as the basis for calculating biological yield. The seeds were then removed and weighed to determine seed yield. The difference between the biological and seed yields was used to calculate the weight of straw per hectare. MSTAT-C was used for statistical analysis of the data, Excel for drawing the diagrams, and Duncan’s test for comparing the means.

Conclusions:

After the initial grouping of the measured data, MSTAT was used for statistical analysis.

Percentage of broken seeds

According to table 1 results of ANOVA the maximum percentage of broken seeds (5.1%) belonged to the Barzegar-e Hamadani planter and the minimum to the Gaspardo and Sfoggia direct planters. The reason for the high percentage of broken seeds in the first planter type was that the seeds were caught in the distributor and were broken.

The table(1)Results of ANOVA percentage of broken seed

Sources of variation	degree of freedom	mean-square	f
Type planting Machines	2	52/715	481/129**
Test error	4	0/462	
Seeding rate	2	1/4	6/2n.s
The interaction between planting and seeding Machines		4 0/163	2/263n.s
Test error		12	0/117

C.V=14/26% *significant difference at the 5%level

**significant difference at the 1%level

n.s=the difference is not significant

Precision of the planters in providing the appropriate longitudinal distance between the seeds

According to table (2) Results of ANOVA indicated there were significant differences between the planters in their provision of longitudinal distance at the 5% level. The highest uniformities in the longitudinal distances between the seeds in planted rows were that of the Gaspardo and Sfoggia direct planters and the lowest that of the Barzegar-e Hamadani planter. The reason for this was that rubber wheels were used in the Barzegar –e Hamadani planter, while the Gaspardo direct planter had steel serrated wheels that penetrated into the soil when they moved (and prevented them from spinning).

The table(2)results of ANOVA uniformity coefficient longitudinal distance

Sources of variation	degree of freedom	mean-square	f
Type planting Machines	2	186/325	44/594*
Test error	4	4/512	
Seeding rate	2	6/54	3/851n.s
The interaction between planting and seeding machines	4	14/851	6/177n.s
Test error		12	2/415

C .V =6/84% *significant difference at the 5% level **significant difference at the 1% level
n.s=the difference is not significant

Percentage uniformity in planting depth

According to table (3) results of ANOVA the highest uniformities in planting depth belonged to the Gaspardo and Sfoggia direct planters with 88.26 and 86.49%, respectively, and the lowest (79.03%) to the Barzegar-e Hamadani planter. The Gaspardo and Sfoggia direct planters had disc-type furrow openers that could easily penetrate into the soil and provide greater uniformity in depth of planting, while the Barzegar-e Hamadani planter had shoe- type furrow openers that lost their depth adjustment if they met terrain variations or hit clods

The table (3)results of ANOVA planting depth uniformity index

Sources of variation	degree of freedom	mean-square	f
Repeat	2	2/983	0/938
Type planting Machines	2	16/827	4/715*
Test error	4	4/48	
Seeding rate	2	10/528	3/422n.s
The interaction between planting and seeding Machines 4		5/473	2/671n.s
Test error		12	4/621

*significant difference at the 5%level **significant difference at the 1% level c.v=7/52%
n.s=the difference is not significant

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Morphological traits

Morphology refers to identification of the physical form and external structure of plants. The ANOVA of some of the morphological traits is presented below.

Plant height

According to table (4) results of ANOVA the effects of planter type and seeding rates on plant height were significant at the 1% level, but their mutual effects on plant height were significant at the 5% level. Planting with the Gaspardo and Sfoggia direct planters produced the tallest plants while the shortest plants were observed in plots planted with the Barzegar-e Hamadani planter. The 240 kg/ha seeding rate resulted in the maximum height of plants while the 160 and 200 kg/ha treatments had the shortest plants. The mutual effects of planter type and seeding rate on plant height showed that the tallest plants belonged to the treatment of using the Sfoggia or Gaspardo direct planter and the seeding rate of 240 kg/ha and the shortest to the treatment of employing the Barzegar-e Hamadani planter and the seeding rate of 160 kg/ha. The plants in direct planting were taller probably because more soil moisture was preserved in this planting practice (which was readily available to the plants in their early stages of growth leading to their more rapid growth). These results conform to those reported by Jones (1969) , Campbell (2000), and Rasnak et al. (1996).

Spike length

According to table (4) results of ANOVA the effects of seeding rate on spike length were significant at the 1% level, but the effects of planter type and the mutual effects of planter type and seeding rate on spike length were not significant. The seeding rates of 160 and 200 kg/ha resulted in the maximum spike length and the treatment with the seeding rate of 240 kg/ha had the shortest spikes.

The table (4) results of ANOVA morphological traits

Sources of variation		mean-square	
	Degree of freedom	plant height	spike lengths
Repeat	2	0/31	0/77
Type planting Machines	2	82/08**	0/81n.s
Error	4	44/22	0/17
Seeding rate	2	11/32**	0/83**
Interaction	4	0/42*	0/55n.s
Error	12	14/08	0/38
Coefficient of variation		7/41%	10/19%

*significant difference at the 5% level **significant difference at the 1% level

n.s =the differences is not significant

Number of spikes per square meter

According to table (5) results of ANOVA indicate the effects of planter type, of seeding rate, and their mutual effects, on number of spikes per square meter were not significant. However, planting with the Gaspardo and Sfoggia direct planters led to the largest number of spikes per square meter while the customary planting with the Barzegar-e Hamadani planter resulted in the smallest number of spikes per square meter. Moreover, the treatment with the seeding rate of 200 kg/ha had more spikes per square meter.

Number of seeds per spike

According to table (5) results of ANOVA the effects of planter type on number of seeds per spike were not significant, but those of seeding rate and the mutual effects of planter type and seeding rate on number of seeds per spike were significant at the 5% level. The three planters were in the same statistical group

with respect to number of seeds per spike, but the treatments with the Gaspardo and Sfoggia direct planters had the highest number of seeds per spike and the Barzegar-e Hamadani the lowest. The treatment with the seeding rate of 200 kg/ha had more seeds per spike, and direct planting with the Gaspardo and Sfoggia planters with the seeding rates of 160 and 200 kg/ha resulted in the highest number of seeds per spike.

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1000-seed weight

According to table (5) results of ANOVA planter type had no significant effect on 1000-seed weight, seeding rate significantly influenced 1000-seed weight at the 5% level, but the mutual effects of planter type and seeding rate on 1000-seed weight were not significant. Although the three planters were in the same statistical group with respect to 1000-seed weight, the treatments with the Gaspardo and Sfoggia direct planters had greater 1000-seed weights. The seeding rate of 200 kg/ha led to the maximum 1000-seed weight, but the seeding rates and planter types were in the same statistical group with respect to 1000-seed weight.

Straw yield

According to table (5) results of ANOVA the three planters were in the same statistical group in relation to straw yield, but the treatments with the Gaspardo and Sfoggia direct planters had higher straw yields. The seeding rate of 240 kg/ha also led to greater straw yield.

Seed yield

According to table (5) results of ANOVA a planter type had no significant effect on seed yield, but the effects of seeding rate and the mutual effects of planter type and seeding rate on seed yield were significant at the 5% level. These results contradict those found by Carlen and Gooden (1997) regarding planting pattern because they stated the customary practice led to the maximum seed yield. However, Bellido et al. (2011) conducted long-term experiments on planting systems and found that in dry years wheat seed yield was higher in direct planting compared to the customary practice because it led to greater conservation of soil moisture. Murdock et al. (2010) reported in their 7-year experiment that wheat yields in direct and customary planting practices were not significantly different, and their results conform to those of our research. The seeding rate of 200 kg/ha led to the maximum seed yield.

The table (5) results of ANOVA of seed yield relater traits

Sources of variation	degree of freedom	the number of Spike	the number of seeds per spike	1000-seed weight	straw yield	seed yield
Repeat	2	7621/31	4285/33	2/14	1287371/36	623855/89
Type planting machines	2	1623/41	480/54n.s	25/88n.s	136914/75n.s	13793n.s
Error	4	1963/24	732/25	6/72	723018/24	237767/23
Seeding rate	2	5886/2n.s	339/14*	8/86*	1024474/6**	1254320*
Interaction	4	397n.s	1428/36*	0/69n.s	76903/87*	25845/55*
Error	12	426/83	247/91	5/147	24081/44	12583/18
Coefficient of variation		5/32	4/71	6/59	3/48	3/86

*significant difference at the 5%level **significant difference at the 1%level n.s=the difference is not significant

Conclusions

Using direct planters to grow wheat after harvesting summer corn, which is concurrent with rainfalls in the region, is a good option because, in case of early fall rainfall events, land preparation for the customary planting practice is considerably delayed. No-tillage planting systems are faster than the customary planting practice and save on machinery movements and adjustments of planting machinery, which results in considerable savings in time.

Comparison of the planters with respect to percentage of broken seeds showed the effects of planter type were significant at the 1% level, and comparison of the means indicated the Barzegar-e Hamadani planter with 5.1% had the maximum and the Gaspardo and Sfoggia direct planters the minimum percentages of broken seeds. The effects of planter type on precision in providing the suitable longitudinal distance between the seeds were significant at the 5% level. Comparison of the means revealed the best uniformity in longitudinal distance between the seeds in planted rows belonged to the Gaspardo and Sfoggia direct planters and the minimum to the Barzegar-e Hamadani planter. The effects of planter type were significant at the 5% level, and the diagram of comparison of the means suggested the best uniformities in planting depth were those of the Gaspardo and Sfoggia direct planters (with 88.26 and 86.49%, respectively) and the worst (79.03%) to the Barzegar-e Hamadani planter.

ANOVA indicated that the three planters were not significantly different in wheat yield, but that there were significant differences between seeding rate treatments at the 5% level. Nevertheless, comparison of the means showed seed yields in the treatments that used the Gaspardo direct planter were 1.32 and 11.13% higher compared to those in which the Sfoggia direct planter and the Barzegar-e Hamadani planter were used (which showed the relative superiority of the Gaspardo direct planter over the other two types). Moreover, comparison of the means revealed that the seeding rate of 200 kg/ha led to yields that were 11.05 and 24.36% higher compared to those obtained at the seeding rates of 160 and 240 kg/ha, respectively.

Results of this research indicated planting with the Gaspardo direct planter using the seeding rate of 200 kg/ha resulted in the highest seed yield and, therefore, could be recommended for the region.

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