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# Performance evaluation of common grain drills in Iran

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Afzalinia, S., Shaker, M. and Zare, E. 2006. **Performance evaluation of common grain drills in Iran.** Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **48**: 2.39 - 2.43. The overall performance index (OPI) of the most common models of grain drills in Iran including Hassia, Nordstone, Hamadan Machine Barzegar, and Keshtgostar was determined under irrigated conditions. To calculate the OPI, parameters such as required draft, field efficiency, effective field capacity, uniformity of the seed planting depth, uniformity of the seed distribution, plant population, possibility of planting seed and fertilizer simultaneously, number of required labourers, the cost of operation, availability of furrower for irrigation, and planted crop yield were determined for each grain drill tested. A randomized complete block design was used to analyze data of this study. Results showed a significant difference between the grain drills for uniformity of the seed planting depth and draft requirement. The Machine Barzegar grain drill had the best planting depth uniformity (81.9%) and the highest draft requirement (7665 N). Comparison of the grain drills for OPI showed that the Hamadan Machine Barzegar grain drill had the highest OPI (0.91). **Keywords:** grain drill, Overall Performance Index (OPI), wheat production.

L'indice de performance globale (IPG) de la plupart des modèles courants de semoirs à grain en Iran, y compris Hassia, Nordstone, Hamadan Machine Barzegar et Keshtgostar, a été déterminé en condition de sol irrigué. Pour calculer le IPG, des paramètres tels la puissance de tirage requise, l'efficacité au champ, la capacité réelle au champ, l'uniformité de la profondeur de semis, l'uniformité de la distribution des semences, la population des plants, la possibilité de semer et de fertiliser simultanément, la main d'œuvre requise, le coût des opérations, la présence de sillons pour l'irrigation et le rendement de la culture ont été déterminés pour chacun des semoirs testés. Un design expérimental en blocs complets randomisé a été utilisé pour analyser les données de cette étude. Les résultats ont démontré des différences significatives entre les semoirs pour l'uniformité de la profondeur de semis et la puissance de tirage. Le semoir Machine Barzegar présentait la meilleure uniformité de profondeur de semis (81,9%) et la puissance de tirage nécessaire la plus élevée (7665 N). La comparaison des semis utilisant l'IPG a démontré que le semoir Hamadan Machine Barzegar avait l'IPG (0,91) le plus élevé. **Mots clés:** semoir, Indice de performance globale (IPG), production de blé.

## INTRODUCTION

Wheat is a major food crop for a growing world population. Planting is one of the most important stages of wheat production; therefore, grain drills used for wheat planting play a significant role in wheat production. There are different models of grain drills available for farmers in Iran, but there is not enough information available for farmers to determine which one is the best for their farm. Therefore, performance evaluation of existing grain drills is necessary to provide

farmers with the required technical information to choose the best grain drill for wheat planting. Nave and Paulsen (1979) compared five different models of seed metering devices for accuracy of the space between planted seeds and mechanical damage to the seeds. They concluded that there was no significant difference between metering systems for seed breakage and seed germination. They also found that the fluted roller meter had the maximum fluctuation for seed spacing. Payton et al. (1985) evaluated six different models of grain drills in no-tillage conditions and reported that the maximum wheat yield resulted from the "Agricultural Engineering I" grain drill.

Senapati et al. (1988) compared the performance of six grain drills for energy requirement, uniformity of seed distribution, and crop yield. They found that the Implement Factory Seed-Cum-Fertilizer grain drill had the best overall performance coefficient. Tessier et al. (1991) evaluated the effect of different no-till drill openers on the seed emergence of wheat. They reported that disk opener increased the percentage of seed emergence and speed of seed germination. Senapati et al. (1992) evaluated the performance of five different models of grain drills in Orissa, India based on eleven important parameters affecting grain drill performance. They assigned a weight to each parameter according to the role of each parameter in the grain drill performance and calculated the OPI for each grain drill. Results of their research showed that the "Gujarat Combined" grain drill had the highest OPI and was the best grain drill for Orissa state in India.

Heege (1993) evaluated four different planting methods in cereals, rapeseed, and beans based on uniformity of planting depth and uniformity of seed distribution over the unit area. He found that the precision drilling method had the best uniformity of planting depth and the broadcast-sowing method had the best uniformity of seed distribution per unit area. In this study, the most prevalent grain drills in Iran were evaluated for overall performance index. Lindwall et al. (1995) reported that a drill with a runner opener increased the wheat yield compared to a disk opener. Tajuddin and Balasubramanian (1995) evaluated the performance of five various drill openers and concluded that the single-disk opener had the best performance among the openers tested. Gratton et al. (2003) designed a spring-loaded downforce system for seeder disc opener as an alternative for the existing hydraulically loaded downforce system. They reported that the spring system caused about 50% smaller variation in downforce under the micro-relief variations tested. The spring-loaded system also showed a faster response in the field tests.

**Table 1. Characteristics of the grain drills tested.**

Grain drill	Type and number of openers	Row spacing (mm)	Effective operating width (mm)	Hopper capacity (L)	Seed metering type
Hassia (DU 100)	Disk - 19	158	3000	360	Fluted wheel
Nordstone (CLGHI250)	Disk - 21	119	2500	430	Fluted wheel
Hamadan Machine Barzegar (KF3-20/4)	Runner - 20	120	2950	360	Fluted wheel
Keshtgostar (DF-250)	Disk - 17	150	2550	450	Stocked roller

Chen et al. (2004) evaluated the effect of soil conditions and drill configurations on the drill and crop performances. They reported that removing press wheels from the planting unit reduced the speed of seed emergence and the plant population in the normal and dry seeding condition, while removing the press wheel increased the speed of seed emergence in the wet soil condition. Removing the gauge wheel in the soft soil condition reduced the speed of seed emergence and plant population due to increased planting depth. They also noted that removing the press and/or gauge wheels reduced the crop yield in the dry and normal seeding conditions. Doan et al. (2005) evaluated the effect of residue type on the performance of disc and hoe type seeder openers under no-till condition. Results of their study showed that the disc opener had better performance for seeding depth and seed emergence, while there was no significant difference between the openers for plant population.

The objective of this study was to compare grain drills with different seed metering systems and furrow openers under irrigated conditions for irrigated wheat in Iran.

### MATERIALS and METHODS

In this research, the four most common grain drills used for planting irrigated wheat in the province of Fars in Iran were evaluated. These grain drills included Hassia (model DU100, Butzbach, Germany), Nordstone (model CLGHI250, Skive, Denmark), Hamadan Machine Barzegar (model KF3-20/4, Hamadan, Iran), and Keshtgostar (model DF-250, Tabriz, Iran). Characteristics of these grain drills are presented in Table 1. Grain drills were evaluated based on eleven parameters such as draft, field efficiency, effective field capacity, planting depth, uniformity of seed distribution, crop yield resulting from the grain drill, possibility of simultaneously planting of seed and applying fertilizer, plant population per unit area, operation cost per unit area, number of required labourers, and availability of furrower for irrigation. Experiments were performed in the province of Fars in Iran with a silty-clay-loam soil, and the variety of the wheat (*T. aestivum*) seed used in this study was Cross Azadi with the seeding norm of 180 kg/ha. Seed bed preparation included plowing with moldboard plow, two times using a disk harrow, and leveling with a land leveler. Grain drills were set to plant at 50-mm depth in the plots with 20-m length and 6-m width, and plots were furrow irrigated. A randomized complete block design with four treatments and four replications was used to analyze the data. In addition to comparing the grain drills for each parameter, the OPI of each grain drill was calculated from Eq.1 (Senapati et al. 1992), and grain drills were compared based on this index.

$$OPI = \sum_{i=1}^n R_i W_i \quad (1)$$

where:

$OPI$  = overall performance index,

$R_i$  = coefficient of measured or observed value of each parameter (Table 2),

$W_i$  = fractional weighting of each parameter in grain drill performance (Table 3), and

$n$  = number of parameters.

### Measurement methods

The required draft for each grain drill was measured using a drawbar dynamometer (TML model TC-21K, Tokyo, Japan). This dynamometer was mounted between two tractors and the grain drills were hooked to the three hitch point on the rear tractor. The draft was recorded once when the grain drill was engaged to the rear tractor and at the second time when the grain drill was detached from the rear tractor. Data were recorded for intervals of 20 s for each plot at a forward speed of 7 km/h. The difference between the two forces was considered as the required draft of the grain drill. To calculate the field efficiency of the grain drills, a field of 200 by 100 m was planted. The planting operation was performed longitudinally with a forward speed of 7 km/h. While planting this area, the effective operating times and the times spent to fill the seed hopper were recorded, and using Eq. 2 (Kepner 1978) the field efficiency was calculated for each grain drill.

$$e = 100 \frac{T_e}{T_t} \quad (2)$$

where:

$T_e$  = effective operating time (min),

$T_t$  = total time (min), and

$e$  = field efficiency (%).

Effective field capacity was also calculated using Eq. 3 (Kepner 1978).

$$C_e = \frac{WSe}{1000} \quad (3)$$

where:

$C_e$  = effective field capacity (ha/h),

$W$  = implement effective width (m), and

$S$  = forward speed (km/h),

To calculate the coefficient of uniformity of seed distribution, a plastic strip with measurements of 20 by 1.5 m was laid flat on the land prepared for planting, and a layer of fine soil of 50-mm thickness was spread out on the plastic strip. Planting was performed on the strip at a speed of 7 km/h. An area of four rows with a length of one meter was randomly selected using a wooden frame in each replication. The planted seeds in this area were separated from the soil using a sieve. The coefficient of uniformity of seed distribution was computed using Eq. 4 (Senapati et al. 1992).

**Table 2. Coefficients of the parameters according to their observed or measured values (from Senapati et al. 1992 with changes according to the conditions of this study).**

Parameter	Range for observed or measured values	Coefficient R
Draft (N)	<13800	1.00
	13800-18350	0.90
	18350-22910	0.70
Effective field capacity (ha/h)	>22910	0.50
	>1.54	1.00
	1.44-1.54	0.90
	1.34-1.44	0.80
	1.24-1.34	0.60
Coefficient of the uniformity of seed distribution (decimal)	<1.24	0.40
	>0.80	1.00
	0.75-0.80	0.90
	0.70-0.75	0.70
	0.65-0.70	0.50
Plant population (plants/m <sup>2</sup> )	<0.65	0.30
	424±5%	1.00
	424±10%	0.80
	424±20%	0.60
Field efficiency (%)	<424±20%	0.40
	>80	1.00
	75-80	0.90
	70-75	0.70
	65-70	0.50
Operating costs (Can\$/ha)	<65	0.30
	<12	1.00
	12-13	0.80
	13-14	0.60
Planting and fertilizing simultaneously	>14	0.40
	yes	1.00
	no	0.00
Uniformity of planting depth (decimal)	>0.80	1.00
	0.75-0.80	0.80
	0.70-0.75	0.70
	0.65-0.70	0.50
	<0.65	0.30
Furrower availability	yes	1.00
	no	0.00
Number of required labourers	1	1.00
	2	0.80
	3	0.60
Crop yield (kg/ha)	optimum	1.00
	<optimum	0.90

$$S_e = 100 \left( 1 - \frac{Y}{D} \right) \quad (4)$$

where:

- $S_e$  = coefficient of seed distribution uniformity (%),
- $Y$  = average numerical deviation of number of plants per meter length of row from average number of plants per meter run, and
- $D$  = average number of plants per meter length of row.

**Table 3. Parameters considered and their fractional weightings (from Senapati et al. 1992 with changes according to the conditions of this study).**

Parameter	Considered weight (W <sub>i</sub> )
Draft	0.1
Effective field capacity	0.2
Uniformity of seed distribution	0.1
Plant population	0.05
Field efficiency	0.05
Operation cost	0.1
Plant seed and fertilizer simultaneously	0.05
Planting depth	0.1
Availability of furrower	0.1
Number of required labourers	0.05
Crop yield	0.1
Total	1.0

To measure plant depth uniformity, planted seeds were irrigated gently and adequate time was provided for seedling emergence. Once emerged, seedlings were cut at the soil surface. A part of the stem that was inside the soil (from soil surface to seed remnants on the root) was taken out and its length was measured. This length was considered as a criterion to compare the seeding depth of the drills. For each plot (6 × 20 m) 20 samples were taken, and the coefficient of planting depth uniformity was calculated using Eq. 5.

$$S_d = 100 \left( 1 - \frac{Y_d}{D_d} \right) \quad (5)$$

where:

- $S_d$  = coefficient of planting depth uniformity (%),
- $Y_d$  = average numerical deviation of depth of seeds planted from pre-set planting depth, and
- $D_d$  = average depth of seeds planted.

Before the tillering stage, the average number of plants on the one meter square of each plot was counted using a one meter by one meter frame. In this case five samples were taken from each plot and the average of these five samples was considered as the plant population per unit area. In the meantime, total operational expenses per unit area for each grain drill were calculated and were considered to be one of the effective parameters on the OPI. To find the crop yield, an area of 20 by 1.65 m was harvested in each plot, and crop yield of each treatment at 13% moisture content was obtained.

## RESULTS and DISCUSSION

Means comparison of the treatments for required draft to pull the grain drills is shown in Table 4. These results show that there was a significant difference between the required draft of grain drills tested. Machine Barzegar required the maximum draft and Keshtgostar required the least draft. Machine Barzegar was the only grain drill that had furrowers for irrigation and these furrowers increased the grain drill draft requirement; therefore, it was logical for Machine Barzegar to have the

**Table 4. Measured parameters of the grain drills.**

Grain drill	Yield (kg/ha)	Total draft (N)	Uniformity of seed distribution (%)	Coefficient of uniformity of planting depth (%)	Plant canopy (plants/m <sup>2</sup> )	Field efficiency (%)	Effective field capacity (ha/h)
Hamadan Machine Barzegar	7685 a*	7665 a	94 a	81.9 a	419 a	71.9	1.48
Hassia	7934 a	1679 b	91 a	74.8 ab	358 a	70.8	1.49
Nordstone	8255 a	1217 c	93 a	70.2 b	395 a	72.9	1.28
Keshtgostar	7743 a	1204 c	92 a	67.6 b	378 a	73.9	1.32
LSD (p=0.05)	1390.5	459.5	4.8	9.23	132.1		

\*Values followed by different letters within each column are statistically different at the 95% confidence level.

**Table 5. Overall performance index of the grain drills.**

Parameters	W <sub>i</sub>	Hassia		Nordstone		Machine Barzegar		Keshtgostar	
		R <sub>i</sub>	W <sub>i</sub> R <sub>i</sub>	R <sub>i</sub>	W <sub>i</sub> R <sub>i</sub>	R <sub>i</sub>	W <sub>i</sub> R <sub>i</sub>	R <sub>i</sub>	W <sub>i</sub> R <sub>i</sub>
Draft	0.10	1.00	0.10	1.00	0.10	1.00	0.10	1.00	0.10
Effective field capacity	0.20	0.90	0.18	0.60	0.12	0.90	0.18	0.60	0.12
Uniformity of seed distribution	0.10	1.00	0.10	1.00	0.10	1.00	0.10	1.00	0.10
Plant canopy	0.05	0.60	0.03	0.80	0.04	1.00	0.05	0.60	0.03
Field efficiency	0.05	0.70	0.035	0.70	0.035	0.70	0.035	0.70	0.035
Operation cost	0.10	0.10	0.10	0.60	0.06	1.00	0.10	1.00	0.10
Planting/fertilizing simultaneously	0.05	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.05
Planting depth	0.10	0.70	0.07	0.70	0.07	1.00	0.10	0.50	0.05
Availability of furrower	0.10	0.00	0.00	0.00	0.00	1.00	0.10	0.00	0.00
Number of required labourers	0.05	0.80	0.04	0.80	0.04	0.80	0.04	0.80	0.04
Crop yield	0.10	1.00	0.10	1.00	1.00	1.00	0.10	1.00	0.10
	$\Sigma W_i R_i$		0.76		0.67		0.91		0.73

maximum draft requirement. The results of analysis showed that Keshtgostar had the highest field efficiency and Hassia had the lowest field efficiency (Table 4). These results also showed that field efficiency was inversely proportional to the machine operating width since increasing operating width decreased the machine maneuvering ability for turning at the end of the field and consequently increased the turning time. However, increasing the operating width decreased the number of turnings at the end of the field; the effect of increasing the turning time was more effective than decreasing the number of turnings.

Comparison of the treatments for effective field capacity is also shown in Table 4. These results show that the Hassia grain drill, in spite of having the lowest field efficiency, had the highest effective field capacity while the Nordstone grain drill had the lowest effective field capacity. Therefore, operating width had more influence on the field capacity than field efficiency.

The data analysis of seed distribution uniformity showed no significant difference between the grain drills for this parameter (Table 4), and all grain drills had a coefficient of seed distribution uniformity greater than 90%. Among the grain drills tested, wheat planted with the Nordstone had the highest crop yield, 8255 kg/ha, and Machine Barzegar had the lowest yield (7685 kg/ha); however, the difference between the grain drills for yield was not statistically significant (Table 4).

There was a significant difference between the treatments for uniformity of seed planting depth (Table 4), and Machine Barzegar had the highest depth uniformity and Keshtgostar had the lowest depth uniformity. With the Keshtgostar grain drill, there was a gap between the metering system outlet and the seed tube inlet; therefore, during the planting operation some of the seeds were scattered on the ground without entering the seed tube and this decreased the uniformity of seed planting depth of this grain drill.

Results of data analysis of the plant population showed no significant difference between the treatments for this parameter; however, Machine Barzegar had the highest number of plants per unit area (Table 4). By comparing plant canopy and crop yield, it was observed that there was no direct relationship between the plant canopy and crop yield. What was more important than the number of plants per unit area was how vigorous the plants were. For this reason, Machine Barzegar, in spite of having the highest plant canopy, had the minimum yield among the grain drills because of the increased planting depth.

Results of the OPI calculation are shown in Table 5. The OPI is the summation of the products of the coefficient of each parameter and its fractional weighting (the role of the parameter in the grain drill performance); therefore, this table summarizes the results of the study. Machine Barzegar grain drill had the maximum OPI; therefore, it was considered to be the best grain

drill for this region of Iran. Hassia, Keshtgostar, and Nordstone were rated as second, third, and fourth, respectively.

### CONCLUSIONS

There was no significant difference between the grain drills for uniformity of seed distribution, plant population, and yield. There was a significant difference between the grain drills for uniformity of seed planting depth, and Machine Barzegar had the highest depth uniformity and Keshtgostar had the lowest depth uniformity. Among the grain drills tested, Machine Barzegar required the maximum draft because of having furrowers for irrigation and Keshtgostar required the least draft. Of the grain drills tested, Hamadan Machine Barzegar grain drill had the maximum OPI and is therefore recommended for planting wheat under irrigation in the Fars province of Iran.

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