FURROW OPENERS AND PRESSWHEELS EVALUATION FOR NO-TILL WHEAT SOWING

BAHRI A.,* VON BARGEN. K**, and BANSAL. R.K.*

ملخص

إن دراستنا هذه تتطرق بالخصوص إلى مقارنة ثلاثة طرق آلية، تهدف إلى غرس البذور بحيث تم استعمال نوعين من عجلات إدخال البذور «الدك» لزرع القمح مباشرة بدون حرث سابق.

هذا وقد تبين في بادية الأمر أن استخدام القرص المزدوج «Double disque»، كان الأكثر نجاحاً في وضع الحبوب بالأماكن المناسبة وذلك بالنسبة للأراضي ذات التربة الهشة.

أمّا المناطق الصلبة التربة والقليلة الرطوبة فكان الصوك «Soc» أفضل من غيره في وضع الحبوب مما ساعد بكثير على إنبات غالبية الحبوب.

وأخيراً نشير إلى أن عجلات «الدك» لم يكن لها أي تأثير يذكر على إنبات الحبوب.

ABSTRACT

Double disc, single disc, and hoe openers combined with double-rib and narrow rounded presswheels mounted on a Type grain drill were evaluated for sowing wheat in no-till conditions . In a relatively soft soil, the double disc opener was found to be suitable for no-till sowing of wheat . However, in hard dry soils, hoe openers performed better than other types of openers because it penetrated the soil more easily . The greater amount of soil disturbance and lower seed row soil bulk density created by the hoe opener improved soil-seed contact giving a better plant stand . The presswheel type had no significant effect on most of the parameters studied . It was observed that good coulters are essential to effectively cut residue to avoid blocking the hoe openers, even if the residue is only 1 to 1,6 t ha^{-1} .

KEY WORDS : Furrow opener, No-till, Conservation Tillage .

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INTRODUCTION

In the semi-arid region of Morocco, water is the most limiting factor for crop production . Mean annual rainfall ranges between 250-450 mm and it is highly variable in terms of total amount and distribution (Watts and El Mourid, 1988) . Thus, conservation of soil moisture for crop production is extremely important . Research has been conducted at the Centre Regional de la Recherche Agronomique (CRRA), Settat, Morocco for a number of years to evaluate alternate soil management practices, including no-till and minimum tillage, to improve crop production, mainly wheat and some food legumes . Results have shown that no-till and minimum tillage practices have potential benefits for stabilizing and increasing wheat yields . Four years research on a vertisol in the semi-arid region of Morocco showed that no-tillage produced significantly better wheat yields than minimum tillage, which in turn was much better than the conventional tillage practices currently followed by farmers (Bouzza, 1990). Kacemi (1992) studied tillage effect on wheat yields in rotation with food legumes and concluded that minimum tillage is superior to conventional tillage for stabilizing wheat yields . The yield advantages from no-till and minimum tillage were attributed to better soil moisture and soil physical status at the beginning of the cropping season that allowed early sowing . However, both researchers found that wheat crop establishment in relatively hard and dry soils with residue from the previous crop left on the surface, was a major problem .

The majority of Moroccan farmers sow small grain cereals (wheat and barley) by broadcasting seeds by hand followed by one pass of an off-set disc harrow for seed covering. Some of the progressive farmers have started using grain drills . However, the conventional grain drills do not have the desired design features for no-till sowing . Grain drill specially suited for no-till sowing are not yet available in Morocco . On the other hand, there is a wide variety of no-till grain drills in Europe and North America . But their designs may not suit Moroccan conditions because of difference in soils and environment. Thus, the research reported in this paper was conducted with an overall objective to determine furrow opener and presswheel selection criteria for no-till wheat sowing in Morocco .

MATERIAL AND METHODS

Field experiments were conducted at Lincoln NE, U.S.A , and two locations in the semi-arid region of Morocco, Sidi El Aydi (SEA) and Jemaat Riah (JR), to evaluate the performance of double disc, single disc, and hoe openers in combination with double-rib and narrow rounded presswheels, for sowing wheat in no-till conditions .The soil texture and the mean annual rainfall for the three sites are given in Table I which shows that Lincoln soils have high proportion of silt, whereas SEA soils have clay and JR soils sand as dominent constituents. The experiment at Lincoln was sown on 23 October 1990 in a field with soybean residue . At each site in Morocco, two fields, one with light wheat residue and the other with light lentil residue, were used for the experiment. The experiment was sown on 14-15 November 1991 at both sites in Morocco The treatments consisted of three types of furrow openers and two types of

presswheels, tested in a randomized complete block design with four replications. A no-till grain drill manufactured by Tye company, Lockney TX, U.S.A, was fitted with three each of double disc, single disc, and hoe openers . This machine has a fixed 20-cm row spacing and it is equipped with 43-cm diameter rippled coulters ahead of the openers . The presswheel treatments consisted of 5.1 x 33 cm narrow rounded and 10.2 x 30.5 cm double-rib presswheels . Each plot was 25 m long and 2 m wide to allow one pass of the Tye grain drill which represented all the three furrow openers followed by either narrow rounded or double-rib presswheels . Observations were recorded only on the middle row for each opener, to avoid border effect . Procedures adopted for recording field observations are briefly described below .

Furrow Profile

The furrow profile observation was recorded to quantify the amount of soil disturbance and change in the soil surface configuration . The furrow profile was traced using a profilometer positioned at right angle to seed rows . The profilometer has a series of pins at 15 mm spacings sliding in a vertical plane . When resting on the ground, the top edges of the pins, marked on the paper, showed the surface profile across the seed rows . The furrow profile was later digitized using Sigma-Scan software and digitizer (Sigma-Scan, 1987) . The standard deviation of the furrow profile observations was taken as the furrow roughness coefficient (RF) (Tessier and Saxton, 1989) . This coefficient provided a quantitative description of soil disturbance caused by each opener and presswheel combination .

Soil Sampling for bulk density and moisture content determination

Soil samples were taken before sowing and from within-the-row after sowing to determine the change in soil bulk density and moisture content . These measurements were taken three times for each treatment in each plot . At Lincoln, NE, soil samples were taken from the top 76 mm soil layer using a hand held soil probe of 23 mm internal diameter . At the both sites in Morocco, a hand held soil probe of 31 mm internal diameter was used and samples were taken from 0-5 cm and 5-10 cm soil layers .

Seed placement

Furrow openers were adjusted in a trial area outside of the experiment before sowing to obtain the desired seed placement depth . This was achieved by changing spring pressure and presswheel height at each opener until all the openers were operating at the desired seeding depth. At JR where the soil was relatively hard, maximum spring pressure was applied to force the openers into the ground . Seeding depth observations were taken at the same time when the final plant emergence was counted . Thirty plants were randomly pulled from each plot and the length from the seed to the beginning of the green tissue on the stem was measured . This length was taken as the effective seeding depth . The treatments were evaluated on the basis of mean seeding depth of 30 plants and the the associated standard deviation values .

Table I : **Soil texture and annual rainfall at the three experiment sites.**

Description	Location		
	Lincoln	SEA	JR
Soil type	Silty-clay loam	Vertisol	Clay loam
Clay (%)	30	60	28
Silt (%)	60	25	13
Sand (%)	10	15	59
Mean annual rain fall (mm)	760	380	380

Table II : **Summary of observations on initial soil physical conditions and residue levels at Sidi El Aydi and Jemaat Riah sites.**

Sites	Soil moisture (%)		Soil bulk density ($Mg\ m^{-3}$)		Residue ($Kg\ ha^{-1}$)
	0 - 5 cm	5 - 10 cm	0 - 5 cm	5 - 10 cm	
Sidi El Aydi					
Cereal stubble	13.7	20.5	1.09	1.16	1190
Lentil stubble	13.3	15.5	1.19	1.27	1470
Jemaat Riah					
Cereal stubble	8.0	13.3	1.30	1.41	1150
Lentil stubble	7.2	10.6	1.21	1.34	1540

Plant Emergence

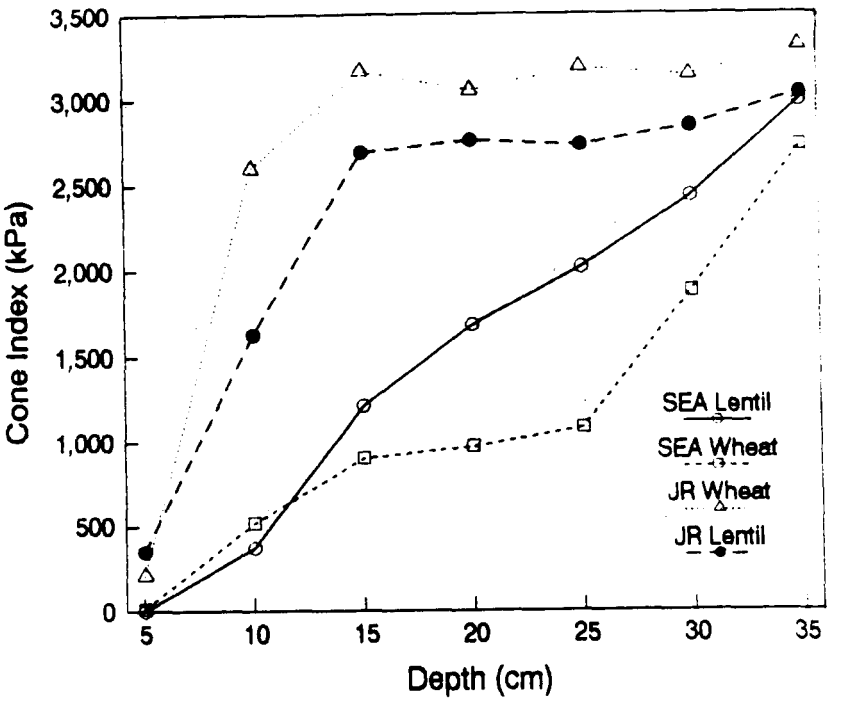
At Lincoln NE, plant counts were taken when the seedlings were about 10cm high . Most plants were at two leaf stage . In the experiments conducted in Morocco, plant counts were taken at 10 days interval starting 20 days after the sowing date to study the rate of emergence .

RESULTS AND DISCUSSION

Initial conditions

Initial soil physical condition and residue levels at both sites in Morocco are given in (Table II) which shows that soils at SEA had more moisture compared to Jemaat Riah . Another significant difference was between wheat and lentil stubble fields . Wheat stubble fields at both locations had higher soil moisture in 5-10 cm layer compared to lentil stubble fields . Bulk density observations taken in 0-5 and 5-10 cm layers showed that soils at JR were more compacted than at SEA . Cone Index data taken by a hand-held cone penetrometer presented in Figure 1 illustrates the same point .

Fig. 1 Cone index observations in wheat and lentil residue fields at SEA and JR sites.



Furthermore, wheat residue field at JR was much more compacted than the lentil residue field . But at SEA, there was not much difference in the soil compaction up to 15 cm depth in the wheat and lentil residue fields . The experimental fields had light residue, in the range of 1.1 to 1.6 t ha^{-1}, from the previous crops even though none of those fields were grazed prior to seeding.

During the sowing operation, soil and residue flow was very good between the single, and the double disc openers . However, the hoe openers occasionally plugged with residue especially where the coulter did not cut it effectively . It happened in wheat residue fields where the straw was moist and not evenly distributed on the soil surface .

Furrow profile

Results from all of the five experiments showed that the effect of furrow opener type on the furrow profile was significant ($P<0.05$) at each location while that of the presswheel was not (Table III) . In general, in a relatively soft soil at Lincoln site. Soil roughness coefficient for single disc opener was higher than that for the other openers (Table III) . In lentil residue fields at both sites in Morocco, the soil disturbance from single disc opener was comparable to the hoe opener . The major difference was that the single disc opener usually opened a wider furrow . The hoe opener penetrated deeper and made a rectangular furrow profile causing considerably more soil disturbance . Occasionally, the RF values were low because soil fell back in the furrow behind the hoe opener .

In both wheat residue fields, the roughness coefficient was highest for hoe opener and least for the double disc opener. There appeared to be some influence of the type of residue on the soil movement by the three types of openers .

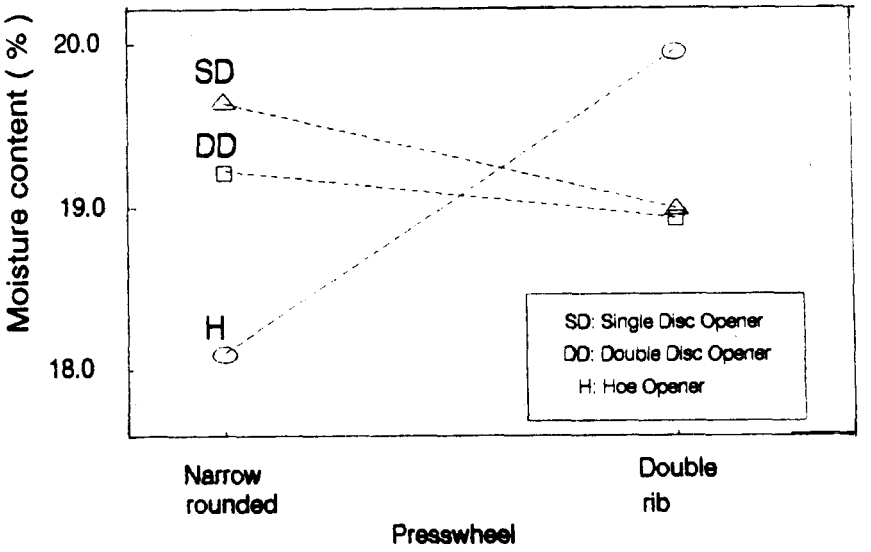
Furrow compaction

At Lincoln NE. no significant differences ($P>0.05$) were found in seed row soil bulk densities of 0-5 cm layer because all openers penetrated to the same depth . However, at both sites in Morocco seed row soil bulk density in 0-5 cm layer was significantly different ($P<0,05$) for the three furrow openers (Table IV) . the presswheel type had no significant effect . In general, 0-5 cm layer soil bulk density for the hoe opener was significantly ($P<0,05$) less than the corresponding values for the other types of openers (Table IV) . This was probably due to the greater amount of soil movement by the hoe openers . Hoe opener seem to have a desired tillage-like action in the seed row on relatively hard soils . The greater amount of soil disturbance and low soil bulk density probably improved seed-soil contact . Soil bulk density observations in 5-10 cm layers did not show any significant effect of the furrow opener and presswheel treatments.

Seed row soil moisture

In the experiment at Lincoln NE, there appeared to be an interaction between the opener type and the presswheel type on seed row soil moisture ($P<0,05$) (Fig.2) . The hoe opener conserved more soil moisture in the seed row when followed by the double-rib presswheel . In contrast, the single disc opener conserved more soil moisture when followed by the narrow rounded presswheel.

Fig. 2 Interaction between Opener and Presswheel in conserving seed row moisture.



Seed row soil moisture data taken after sowing at both sites in Morocco are presented in Table V . The soil moisture content was recorded somewhat higher after sowing the experiment compared to initial soil moisture given in Table II, especially in the top 5 cm layers . This was because 3mm rain at SEA and 4 mm rain at JR was received during the intervening period . Perhaps, this rainfall erased the treatment effect to some extent . At SEA, the effect of treatments was not significant on seed row soil moisture in 0-5 cm and 5-10 cm depths, except in the case of the top 0-5 cm layer in lentil residue field (Table V) . At JR, even though furrow openers had a significant effect on seed row soil moisture in the wheat residue field, the differences were very small . In general, double-rib presswheels seem to have been more effective in furrow closing and soil compaction. Concerning the opener type, seed rows sown with the hoe openers had slightly more soil moisture, but this trend was not consistent .

Seeding depth

Before sowing the experiments, each furrow opener was carefully adjusted to get an optimum seeding depth. However, the openers resulted in different seeding depths, especially in the wheat stubble fields where the residue was tougher and unevenly distributed .

At Lincoln NE, seeding depth from the three types of openers did not differ significantly (P>0,05) regardless of the type of presswheel used (Table VI) . This was because the soil was quite soft at seeding time . Standard deviations of seeding depths (Table VII) show that the double disc opener maintained relatively better seeding depth uniformity compared to the other two openers .

Table III : **Degree of roughness (Rf) of furrow profile .**

Factors	Lincoln	SEA Wheat	SEA Lentil	JR Wheat	JR Lentil
I. Opener					
Hoe	14,5 a*	18,2 a	15,2 a	15,2 a	14,9 a
Double disc	14,5 a	10,9 b	11,9 b	8,3 b	10,1 b
Single disc	17,1 b	14,1 c	15,2 a	11,2 c	14,4 a
II. Presswheel					
Double-rib	15,3 c	14,2 d	14,3 c	12,3 d	13,3 c
Narrow-rounded	15,4 c	14,5 d	14,0 c	10,9 d	12,9 c

* Means followed by the same letter are not significantly different (P>0,05)

Table IV : **Seed row soil bulk density (Mg m^{-3}) for 0-5 cm**

Factors	Lincoln	SEA Wheat	SEA Lentil	JR Wheat	JR Lentil
I. Opener					
Hoe	1,28 a*	1,04 a	1,03 a	1,38 a	1,31 a
Double disc	1,26 a	1,08 b	1,06 a	1,51 b	1,39 b
Single disc	1,27 a	1,09 b	1,11 b	1,44 ab	1,36 ab
II. Presswheel					
Double-rib	1,28 b	1,07 c	1,07 c	1,47 c	1,37 c
Narrow-rounded	1,26 b	1,06 c	1,06 c	1,42 c	1,34 c

* Means followed by the same letter are not significantly different (P>0.05)

Table V : **Seed row soil moisture (%) at both sites in Morocco .**

Factors	SEA Wheat	SEA Lentil	JR Wheat	JR Lentil
In top 5 cm layer				
I. Opener				
Hoe	17,1 a*	15,5 a	10,4 a	10,5 a
Double disc	18,2 a	15,3 a	9,6 b	9,9 a
Single disc	17,1 a	14,4 b	9,3 c	10,0 a
II. Presswheel				
Double-rib	17,7 b	16,0 c	9,8 c	10,0 b
Narrow-rounded	17,7 b	14,1 d	9,8 c	10,2 b
In top 5 cm layer				
I. Opener				
Hoe	20,4 a*	19,1 a	12,6 a	12,8 a
Double disc	20,6 a	19,7 a	12,2ab	12,9 a
Single disc	201 a	19,0 a	12,0 b	13,1 a
II. Presswheel	20,6 b			
Double-rib	20,1 b	19,4 b	12,5 c	13,1 b
Narrow-rounded		19,2 b	11,9 d	12,7 c

* Means followed by the same letter are not significantly different (P>0,05)

Table VI : **Seeding depth (cm)**

Factors	Lincoln	SEA Wheat	SEA Lentil	JR Wheat	JR Lentil
I. Opener					
Hoe	3,0 a*	5,7 a	5,9 a	4,1 a	4,4 a
Double disc	3,3 a	5,5 a	6,1 a	3,6 b	4,0 a
Single disc	3,0 a	5,0 b	6,1 a	3,5 b	4,3 a
II. Presswheel					
Double-rib	3,2 b	5,3 c	6,0 b	3,9 c	4,2 b
Narrow-rounded	3,0 b	5,4 c	6,1 b	3,5 d	4,3 b

* Means followed by the same letter are not significantly different (P>0,05)

Table VII : **Standard deviations of seeding depths obtained from different openers and presswheel combinations .**

Factors	Lincoln	SEA Wheat	SEA Lentil	JR Wheat	JR Lentil
I. Opener					
Hoe	5,8 ab*	5,5 a	5,9 a	7,1 a	6,6 a
Double disc	4,1 a	3,9 b	4,4 a	6,4 ab	5,3 a
Single disc	6,2 b	6,0 a	7,9 b	5,4 b	6,4 a
II. Presswheel					
Double-rib	4,8 c	5,6 c	6,1 c	6,1 c	5,8 b
Narrow-rounded	5,9 c	4,6 d	6,1 c	6,5 c	6,5 b

* Means followed by the same letter are not significantly different (P>0,05)

At SEA, 5-6 cm seeding depth obtained by all the three opener types was quite satisfactory (Table VI) . However, seeding depth of 3,5-4,5 cm obtained at JR was somewhat shallow . This was mainly due to higher soil compaction and less soil moisture at JR (Table II) . In lentil fields there was no significant difference (P>0,05) among the type of openers . However in the wheat stubble fields, the hoe opener appeared to have penetrated deeper than the other two openers . Also, the average seeding depth was more in the lentil residue field than in the wheat residue field at the same site. In general, the presswheel type had no effect on seeding depth .

Plant stand

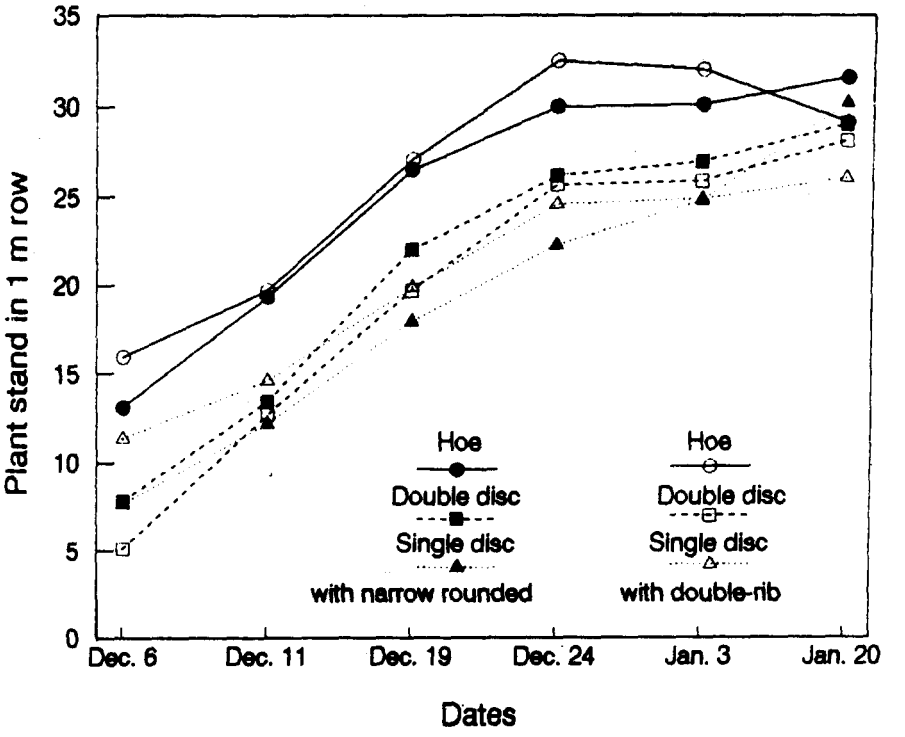
Plant stand is the ultimate test of a furrow opener as it reflects an overall effect of all other factors discussed above . Plant stand observations at Lincoln showed that the double disc opener performed significantly (P>0,05) better than both single disc and hoe openers (Table VIII) . It may be due to more uniform seeding depth obtained by the double disc opener . On an average, 46 plants in 1m row length were counted for the double disc opener compared to 33 for the hoe opener and 31 for the single disc opener . Some interaction was observed in the opener type and the presswheel type . Hoe opener followed by double-rib presswheel had a higher plant emergence compared to the hoe opener and narrow rounded presswheel combination . In contrast, single disc opener performed better with narrow rounded presswheel .

Table VIII : **Comparison of furrow openers and presswheels based on emerged plant population means at Lincoln, NE experiment.**

Furrow opener	Presswheel		
	Double rib	Narrow rounded	Mean
	- - - - - - - - - - - - - - Plant stand in 1 m row- - - - - - - - - - - - -		
Hoe	37.2	29.7	33.4b*
Double disc	45.4	46.0	45.7a
Single disc	26.4	35.8	31.1b
Mean	36.3c	37.13c	
LSD (5%) CV = 29%	9.30		11.39

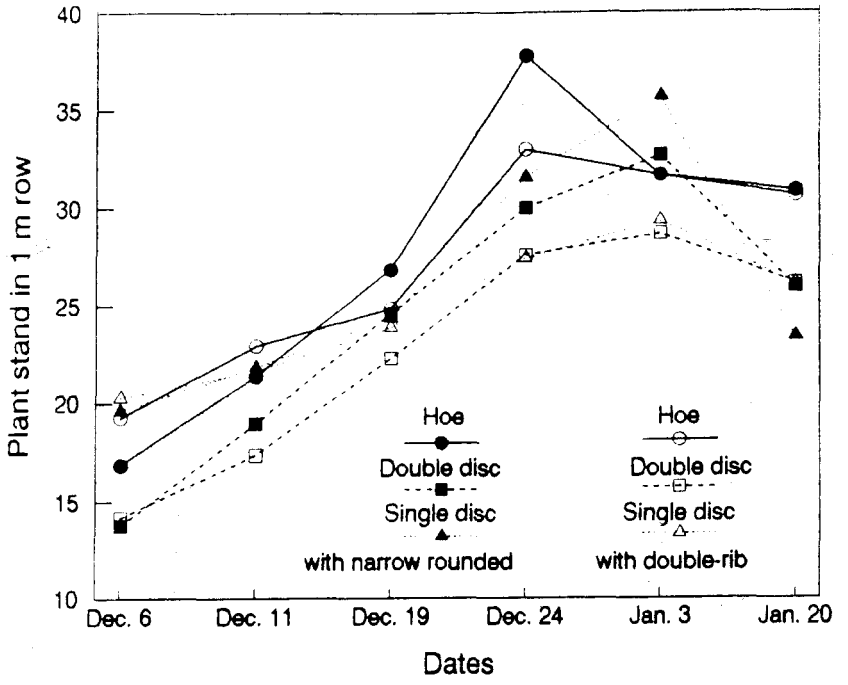
* Means followed by the same letter are not significantly different (p> 0. 05)

Fig. 3 Plant stand on different dates in wheat residue field at Sid El Aydi.



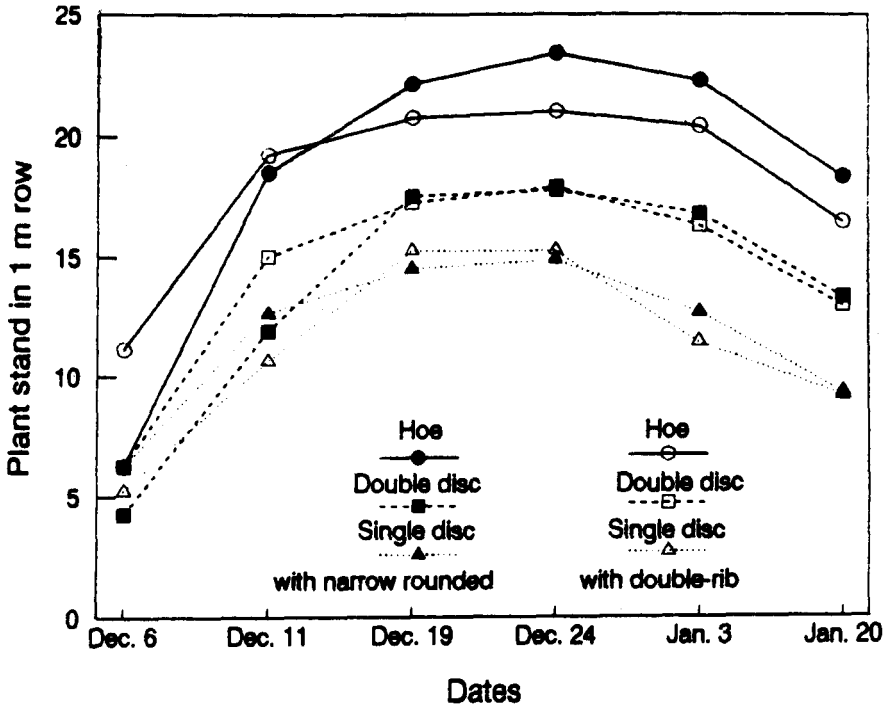
The plant stand data from wheat and lentil residue fields at SEA and JR in Morocco is presented in Figures 3-6, respectively . These graphs show that the number of plants increased steadily for all treatments up to December 24, and in some cases up to January 3 . Observations taken on January 3 and january 20 showed that in all treatments plant stand had either stabilized or tended to decline from a prolonged drought . It can also be seen that the maximum plant stand achieved at SEA was between 30 and 35 plants in 1 m row, depending up on the treatment and the residue situation . In comparison, maximum plant stand in 1 m row at JR was less than 25 in wheat residue fields and around 15 in lentil residue fields . These differences in plant stand reflect the differences between the two sites in terms of initial soil physical condition and soil moisture (Table II) .

Fig. 4 Plant stand on different dates in lentil residue field at Sidi El Aydi.



Figures 3 and 5 show that in the wheat residue fields , the plant stand was always best from the hoe opener followed by double disc and single disc openers, in that order . In the lentil residue fields (Fig. 4 and 6), the differences among the openers were not so clear, perhaps because the type of openers had no significant effect on seeding depth . The hoe opener and the double disc opener gave similar plant stands in both lentil residue plots . The factors that seem to have improved the performance of the hoe opener were the greater amount of soil disturbance in the furrow, and somewhat deeper seed placement, particularly in the wheat residue fields . Perhaps soil movement in the course of seeding operation improved seed-soil contact leading to better germination . The presswheel did not seem to have made a significant difference on plant stand in any of the experiments at SEA or JR .

Fig. 5 Plant stand on different dates in wheat residue field at Jemaat Riah.

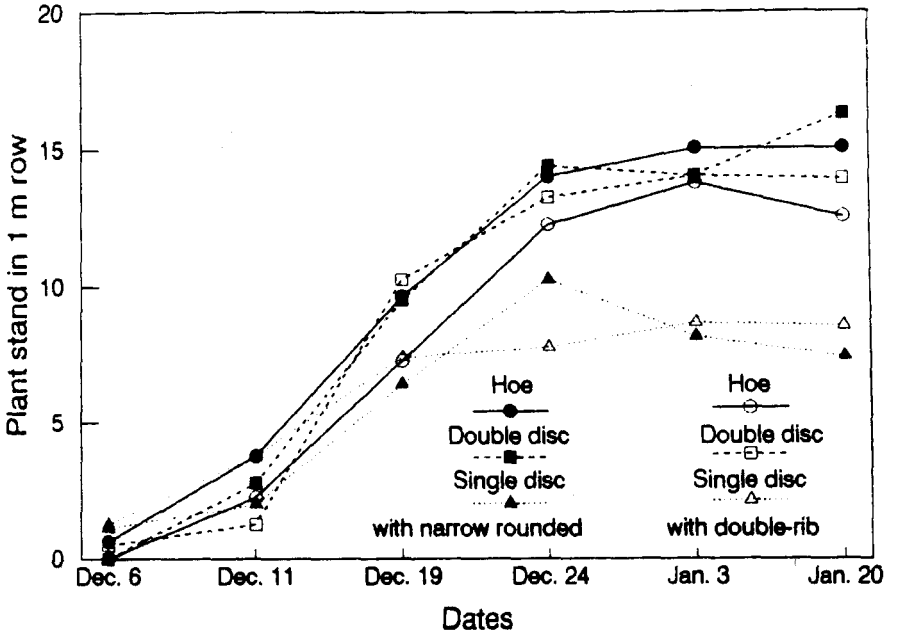


SUMMARY AND CONCLUSION

Double disc, single disc, and hoe openers combined with double-rib and narrow rounded presswheels mounted on a Tye no-till grain drill were evaluated for sowing wheat in no-till conditions at three sites : one at Lincoln, NE , U.S.A. and two in the semi-arid region in Morocco . The soils, residue cover in terms of its source and quantity, and soil physical condition at the time of sowing wheat were quite different at those three sites .

Results showed that for relatively soft and moist soils, such as those encountered at Lincoln, the double disc opener is the most suitable for no-till sowing of wheat .

Fig. 6 Plant stand on different dates in lentil residue field at Jemaat Riah.



However, if the soils at the time of sowing are quite dry and hard, as encountered at both sites in Morocco, a hoe opener design is better suited because it can penetrate the soil more easily . The hoe opener also had a tillage-like effect in the furrow, compared to other types of openers, which improved seed-soil contact and gave a higher plant stand . The presswheel type had no significant effect on most of the parameters studied, particularly at both sites in Morocco . However, the double-rib presswheel appeared to have done better seed covering and soil compaction than the narrow rounded presswheel . It is also important to have good coulters ahead of the hoe openers to effectively cut residue and avoid blocking of furrow openers, even if the residue is light, 1 to 1,6 t ha^{-1}.

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