PERENNIAL FORAGE GRASSES AS AFFECTED BY DEPTH, RATE, AND DATE OF SEEDING IN A SEMI-ARID AREA OF CENTRAL MOROCCO

A. ARIF [1]

SUMMARY

Three experiments were conducted to determine optimum depth, rate, and date of seeding of seven perennial forage grasses under field conditions in a semi-arid area of central Morocco. These include *Agropyron cristatum* (L.) Gaertn. cv.'Fairway', *Agropyron elongatum* (Host.) Beauv. cv. 'Jose', *Agropyron trichophorum* (Link) Richt. cv. 'Luna', russian wildrye (*Elymus junceus* Fisch.), *Phalaris tuberosa* L. cv. 'Sirosa', *Cenchrus ciliaris* L. and *Eragrostis curvula* (Schrad.) Nees. All experiments started during the growing season 1987-88 and were repeated during 1988-89. For the seeding depth experiment, seeds were planted at depths of 1, 4, and 7 cm. The second study evaluated three rates of seeding: 100, 200, and 400 pure live seeds m^{-2}. The third study consisted in planting perennial grasses at three dates each growing season: 19 November 1987, 9 January 1988, 17 February 1988, 21 November 1988, 17 January 1989, and 8 March 1989. In all experiments, establishment was evaluated from seedling counts at the end of the growing season. During the following season and for the seeding rate and date experiments only, stand density, herbage production and forage quality were measured.

Results show a consistent decrease in percentage emergence as planting depth increased and optimum planting depth was 1 cm for *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, and *Eragrostis curvula*. *Phalaris tuberosa* may be seeded at depths between 1 and 4 cm. As to seeding rate, stands seeded at 400 pure live seeds m^{-2} invariably had the highest numbers of plants per unit area. By the second growing season, however, each species produced a similar amount of herbage regardless of initial seeding rate. Increasing seeding rate from 100 to 400 pure live seeds m^{-2} affected neither herbage production nor forage quality. For the seeding date experiment, cool-season species: *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, and *Phalaris tuberosa* may be seeded from November to early January with no significant decrease in establishment or productivity. It is, however, recommended that planting of these perennials be delayed till weeds emerge by late December. Warm-season species, *Cenchrus ciliaris* and *Eragrostis curvula*, should be seeded in November.

[1] **INRA/Programme Aridoculture, B.P. 589, Settat**

Key words: Perennial grasses, seeding depth, seeding rate, seeding date establishment, biomass production, nutritive value.

RESUME

Trois expérimentations ont été conduites pour déterminer la profondeur, la dose, et la date optimales de semis de sept graminées perennes sous les conditions de champ dans une région semi-aride du Maroc. Les espèces utilisées dans cette étude sont: *Agropyron cristatum* (L.) Gaertn. cv.'Fairway', *Agropyron elongatum* (Host.) Beauv. cv. 'Jose', *Agropyron trichophorum* (Link) Richt. cv. 'Luna', russian wildrye (*Elymus junceus* Fisch.), *Phalaris tuberosa* L. cv. 'Sirosa', *Cenchrus ciliaris* L. and *Eragrostis curvula* (Schrad.) Nees. Tous les essais ont commencé pendant la saison 1987-88 et ont été répétés pendant 1988-89. En ce qui concerne la profondeur de semis, les semences ont été plantées à des profondeurs de 1, 4, et 7 cm. Dans le deuxième essai, trois doses de semis ont été étudiées: 100, 200, et 400 semences viables m^{-2}. Le troisième essai a consisté à planter les graminées perennes à trois dates chaque année: 19 Novembre 1987, 9 Janvier 1988, 17 Février 1988, 21 Novembre 1988, 17 Janvier 1989, et 8 Mars 1989. La réussite d'installation a été estimée à partir de comptage de plantules à la fin de la première saison. Durant la saison suivante et pour les essais dose de semis et date de semis, la densité, la production de biomasse, et la qualité fourragère ont été mesurées.

La levée a diminué au fur et à mesure que la profondeur de semis a augmenté et la profondeur optimale de semis a été de 1 cm pour les espèces *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, et *Eragrostis curvula*. *Phalaris tuberosa* peut être semé à des profondeurs allant de 1 à 4 cm. Pour la dose de semis, la levée a été maximale quand les espèces de graminées ont été semées à la dose de 400 semences viables m^{-2}. Cependant, une année après le semis, l'effet dose de semis n'était plus évident, et les graminées ont produit la même quantité de biomasse quelque soit la dose de semis initiale. Pour la date de semis, les résultats montrent que les espèces: *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, et *Phalaris tuberosa* peuvent être semées de novembre à janvier sans pour autant affecter leur productivité. Les espèces *Cenchrus ciliaris* et *Eragrostis curvula* doivent être semées en Novembre.

Mots clés: Graminées pérennes, profondeur de semis, dose de semis, date de semis, installation, biomasse fourragère valeur nutritive.

INTRODUCTION

Forage resources in semi-arid areas of Morocco are currently limited to annual grasses and forbs. Perennial forage grasses, extensively used in other Mediterranean regions may fit into dryland production systems and provide more security and flexibility to livestock producers. They need only be seeded once, alleviating annual planting problems and expense. Established stands of perennial grasses usually produce more herbage than stands of annual species and their yield vary less between years (Hoen 1968).

Perennial grasses, however, are slow to establish and are sensitive to competition from weeds during the first year. To increase chances of stand establishment, cultural techniques should be mastered before large scale use of these species.

Because no information is available on cultural techniques of perennial grasses under semi-arid conditions of Morocco, this study was designed to evaluate the effect of seeding depth, seeding rate, and seeding date on stand performance and productivity of seven perennial forage grasses under field conditions.

MATERIALS AND METHODS

Effects of seeding depth, seeding rate, and seeding date on stand performance and productivity of seven perennial forage grasses under field conditions were conducted in two experimental stations. Seeding depth and seeding rate experiments were conducted at the agricultural experimental station of Sidi El Aydi, 60 km south of Casablanca. The soil in this site is medium-deep clay, calcixero-chromoxerert (paravertisol). Average annual rainfall is 386 mm with large year-to-year variations in both total and seasonal precipitations. Seeding date experiments were conducted on deep clay, chromoxerert soil (vertisol) at the agricultural experimental station of Jemaa Shaim, 230 km southwest of Casablanca. Average annual rainfall on this site is 275 mm. Both sites have a Mediterranean-type climate with wet winter and spring, and hot, dry summer.

Perennial grasses used in all studies included five cool-season species: 'Fairway' crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.], 'José' tall wheatgrass [*Agropyron elongatum* (Host.) Beauv.], 'Luna' pubescent wheatgrass [*Agropyron trichophorum* (Link) Richt.], russian wildrye (*Elymus junceus* Fisch.), 'Sirosa' hardinggrass (*Phalaris tuberosa* L.), and two warm-season species: buffelgrass (*Cenchrus ciliaris* L.) and weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees]. These species were selected because they performed well in a previous study (Arif et *al.*, 1989).

Experimental plots were prepared with two passes of an offset-disc plow, and then harrowed. Nitrogen and phosphorus fertilizers were applied according to soil nutrient status (Soltanpour et *al.* 1987). Weeds were controlled by plowing the soil before planting. Afterwards, weeds were controlled either manually using hand labor, or chemically with Certrol-H [360 g ioxynil + 120 g 2-(2-methy-4-chlorophenoxy) propionic acid in 1 liter of water] at 2 L ha^{-1}. For the seeding date and seeding rate experiments during the second year of establishment, whole plots were mowed with a sickle and total green weights recorded. A subsample of the green herbage harvested on each plot was oven- dried at 60 C for 48 hours, and all herbage yields were calculated on an oven-dry matter basis. Forage analyses included neutral detergent fiber (NDF) and *in vitro* dry matter digestibility (IVDMD). IVDMD values were determined from a modified Tilley and Terry (1963) technique. Because there was no notable effect of seeding rate or date on forage quality, NDF and IVDMD were determined only for the experiments that started during the growing season 1987-88.

Seeding depth experiment

Three seeding depths were tested: 1, 4, and 7 cm. The individual plot size was 3x2 m with rows running the width of the plots. Planting occurred on 11 December 1987 for the 1987-88 experiment and on 15 November 1988 for the 1988-89 experiment. Seeds were hand-planted in 2-m long, 50-cm spaced rows. Stand establishment was determined by counting seedlings in 1-m row inside each plot at the end of the growing season (May). All seedling counts were reported on a pure live seed (PLS) basis. Treatment design was a split-plot with 7 species as whole-plots and seeding depths as sub-plots. Whole plots were arranged in randomized complete blocks with three replications.

Seeding rate experiment

Planting was carried out on 1 December 1987 and on 16 November 1988 for the 1987-88 and 1988-89 field experiments, respectively. Seeds of all species were hand-broadcast at bottoms of 15 cm deep, hand-formed furrows, and covered to about 2-cm depth. Seeds of weeping lovegrass were pushed into the soil by foot because of their small size (Heady 1975). Three seeding rates were tested: 100, 200, and 400 PLS m^{-2}. The individual plot size was 3x2 m with 5 rows running the length of the plots at 0.35-m spacing. Stand establishment was determined randomly by counting seedlings in 1 m of row for two rows inside each plot at the end of first growing season (May). During the second year of establishment, plant density was measured as above, and herbage yield was estimated from 2 cuttings: 10 March and 24 May in 1989, and 21 February and 14 May in 1990. The experiment was laid out as randomized complete blocks with three replications. Treatment design was a factorial with 7 species by 3 seeding rates.

Seeding date experiment

Seeds were hand-broadcast at bottoms of 15-cm deep, hand- formed furrows and then covered to about 2-cm depth. Seeds of weeping lovegrass were covered to less than 1-cm deep because of their small size (Heady 1975). Seeding rate was 200 pure live seeds (PLS) m^{-2} the first year because of limited seed stock and 300 PLS m^{-2} the second year. Each plot consisted of five rows, 3 m long with 0.35 m spacing. Planting dates were 19 November 1987, 9 January 1988, and 17 February 1988 for the 1987-88 experiment; and 21 November 1988, 17 January 1989, and 8 March 1989 for the 1988-89 experiment. The experiment was laid out as randomized complete blocks with three replications. Treatment design was a factorial with 7 species by 3 planting dates. Plant density was determined by randomly counting seedlings in 1 m of row for two rows within each plot at the end of first growing season and during the following season. During the second growing season of each experiment, plots were harvested at 2 periods: mid-February and mid-May.

For all experiments, data were analyzed by standard analysis of variance (ANOVA). Waller-Duncan's multiple range test or the orthogonal contrast method when appropriate were used to separate treatment means (Steel and Torrie 1980). Note that in the following, 1987-88 corresponds to the first experiment started in 1987-88, and 1988-89 corresponds to a similar experiment repeated during the second growing season 1988-89.

During both growing seasons total rainfall (mm) was above average at Sidi El Aydi: 493 mm in 1987-88 and 498 mm in 1988-89 (Table 1). Average daily temperatures (°C) in both growing seasons were similar. At Jemaa Shaim, total rainfall totaled 475 mm in 1987-88 and 434 mm in 1988-89 growing season. In 1987-88, rainfall was more frequent at the beginning and middle of the growing season, whereas in 1988- 89 it was more evenly distributed throughout (Table 2).

Table 1. Monthly minimum (Tmin) and maximum (Tmax) temperatures and rainfall (Prec), Sidi El Aydi.

Season	1987-88			1988-89		
Months	Tmax (°C)	Tmin (°C)	Prec (mm)	Tmax (°C)	Tmin (°C)	Prec (mm)
SEP	35.9	17.0	13.4	35.1	15.6	0.0
OCT	25.5	12.7	38.3	28.5	12.5	49.2
NOV	21.5	9.0	62.2	24.5	11.4	100.2
DEC	20.9	8.8	139.8	21.7	6.1	5.0
JAN	17.4	5.6	113.6	18.4	3.8	35.0
FEB	18.3	5.7	73.5	19.4	4 3	36.7
MAR	23.0	5.6	14.8	22.7	5.9	71.5
APR	24.0	7.8	1.5	19.3	6.9	183.5
MAY	24.7	10.4	35.6	27.4	10.5	16.7

Table 2. Monthly minimum (Tmin) and maximum (Tmax) temperatures and rainfall (Prec), Jemaa Shaim.

Season	1987-88			1988-89		
Months	Tmax (°C)	Tmin (°C)	Prec (mm)	Tmax (°C)	Tmin (°C)	Prec (mm)
OCT	23.2	11.1	70.5	24.9	10.7	23.0
NOV	20.5	3.7	60.5	22.1	10.4	189.0
DEC	20.2	3.1	91.5	19.7	-0.7	3.5
JAN	15.0	3.1	126.0	18.4	-2.5	62.5
FEB	17.6	7.9	44.2	20.1	1.0	40.0
MAR	25.8	9.5	68.5	24.2	5.0	67.5
APR	32.2	10.3	0.0	20.9	4.7	45.5
MAY	26.5	10.7	14.0	29.7	10.5	0.0

RESULTS AND DISCUSSION

1. Seeding depth

1.2 Stand establishment

There was a significant effect of depth on stand density ($P<0.05$). In the following, the effect of seeding depth on each grass species is discussed.

Agropyron cristatum: Percentage establishment varied from 25% at 1-cm depth to nil at the 7-cm planting depth in 1987-88 (Table 3). In the 1988-89 experiment, these values varied from 14% to 4.4% for the same depths respectively. Establishment was lower in 1988-89 but the relative decrease in plant establishment was less pronounced than that recorded in the 1987-88 experiment. In both years, establishment was best from the 1-cm depth.

Agropyron elongatum: This species established better than most species in both experiments (Table 3). There was, however, a sharp decrease in stand density with increased planting depth. Establishment was best from 1-cm depth, and poorest from deeper plantings.

Agropyron trichophorum: Stand establishment was high and was similar to that of *A. elongatum* in all aspects. The 1-cm seeding depth gave the highest establishment (Table 3). All other depths significantly reduced grass stand.

Elymus junceus: this species had good establishment percentages, especially from shallower depths during both years (Table 3). It was, however, more sensitive to deeper planting. Seeding this species at 1-cm depth gave the best results.

Phalaris tuberosa: There was no difference in stand establishment between 1- and 4-cm depths in both experiments. This gives a larger range of depths at which this species may be seeded. Planting at 7-cm depth reduced stand in the first but not in the second experiment. It is recommended, however, that this species be planted no deeper than 4 cm.

Cenchrus ciliaris and *Eragrostis curvula*: *Cenchrus ciliaris* did not establish at any depth in both experiments. Establishment failure may be related to soil type. This species is best adapted to light-textured soils (Schwendiman and Hawk, 1978). On the other hand, *Eragrostis curvula* established from 1-cm depth, but had lower stand establishment than that of cool-season species (Table 3). Seeds of this species are particularly small and should be covered to less than 1-cm deep.

Table 3. Stand density per 100 viable seeds (%) of seven perennial forage grasses measured at the end of first growing season for 1987-88 (Exp1) and 1988-89 (Exp2) field experiments (Sidi El Aydi).

Planting year	1987-88			1988-89		
	Planting depth			Plantind depth		
Species	1 cm	4 cm	7 cm	1 cm	4 cm	7 cm
Agropyron cristatum	24.7ab	0.7b	0.0a	14.2b	11.0b	4.4bc
A. elongatum	35.7a	18.3a	3.3a	23.6a	18.0a	9.7a
A. trichophorum	35.0ab	19.3a	5.0a	21.1a	17.7a	10.6a
Elymus junceus	30.0ab	8.3ab	0.4a	24.4a	14.9ab	0.9c
Phalaris tuberosa	22.0b	11.0ab	0.3a	9.2c	12.3b	8.5ab
Eragrostis curvula	8.3c	0.3b	0.7a	4.9c	0.0c	0.0c
Cenchrus ciliaris	0.0c	0.0b	0.0a	0.0d	0.0c	0.0c

Contrasts	Agropyron cristatum		Agropyron elongatum		Agropyron trichophorum		Cenchrus ciliaris		Elymus junceus		Eragrostis curvula		Phalaris tuberosa	
	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2
1 vs 4 cm	**	ns	*	ns	*	ns	-	-	*	*	*	*	ns	ns
1+4 vs 7 cm	**	*	**	*	**	*	-	-	*	**	ns	ns	**	ns

Means within a column with same letter are not significantly different ($P > 0.05$).
*,** = contrast significant at 0.05 and 0.01 probability level, respectively. ns = not significant.

2. *Seeding rate*

2.1. Stand establishment

During the year of establishment, the better grass stands occurred on plots seeded at the higher rates (Table 4). Increasing seeding rates from 100 to 200 PLS m^{-2} significantly increased plant density of *Elymus junceus*, *Phalaris tuberosa* and *Eragrostis curvula* in the 1987-88 experiment. However, no significant differences ($P>0.05$) existed between densities from those two depth treatments in 1988-89 experiment. Stand densities from the 400 seeding rate were significantly higher ($P<0.05$) for *Elymus junceus* and *Eragrostis curvula* in 1987-88, and for *Agropyron cristatum* in 1987- 88 and 1988-89. *Agropyron elongatum*, *A. trichophorum*, and *Cenchrus ciliaris* were not affected by seeding rate in both experiments (Table 4). When averaged over cool-season species and years, densities at the end of first growing season were 40, 58, and 67 plants m^{-2} for the 100, 200 and 400 rates, respectively. Warm-season species had lower densities than cool-season species at all seeding rates. They showed a peak in stand establishment at the 200 seeding rate, but this never exceeded 32 plants m^{-2} for *Eragrostis curvula* and 13 plants m^{-2} for *Cenchrus ciliaris* in both years.

Additional observations during the subsequent growing season, showed that the effect of seeding rate was no longer noticeable ($P>0.05$). Stand densities were reduced because of intra-specific competition at the higher seeding rates but also because of plant mortality over the dry summer period. Average densities were 10 and 2 plants m^{-2} for cool- and warm-season species, respectively (Table 5).

2.2. Herbage production and forage quality

There was a significant difference in herbage production among species ($P<0.05$). Production was high for *Agropyron elongatum* and *Phalaris tuberosa*, intermediate for *Agropyron trichophorum*, and low for the other species. For a given species, however, herbage production was not affected by seeding rate. All species produced alike amounts of herbage regardless of initial seeding rate. Apparently, this is the optimum the soil can support under existing soil fertility and climatic conditions. Harper (1977) defined this limit as the carrying capacity of the environment.

Forage quality of the herbage produced by each species was not affected by seeding rate. Neutral detergent fiber content and in- vitro dry matter digestibility values were averaged over seeding rates and are reported (Table 6).

Table 4. **Effect of seeding rate on density of plants at the end of first season for the 1987-88 (Exp1) and 1988-89 (Exp2) experiments (Sidi El Aydi)**

Planting year	1987-88			1988-89		
	Seeding rate Plants m^{-2}					
	100	200	400	100	200	400
Species						
Agropyron cristatum	35.3a	33.3bcd	61.7b	38.1a	54.3b	70.5a
A. elongatum	41.0a	52.7ab	67.7b	45.7a	63.3b	64.8a
A. trichophorum	38.0a	50.7abc	62.3b	47.6a	62.4b	67.1a
Elymus junceus	29.7a	61.0a	89.3a	44.8a	91.9a	91.0a
Phalaris tuberosa	32.3a	55.3ab	46.0c	46.7a	52.4b	54.3ab
Eragrostis curvula	8.7b	28.3cd	32.3d	4.8b	17.6c	20.0bc
Cenchrus ciliaris	4.7b	13.3d	13.3e	0.0b	1.9c	1.4c

Contrasts	Agropyron cristatum		Agropyron elongatum		Agropyron trichophorum		Elymus junceus		Phalaris tuberosa		Eragrostis curvula		Cenchrus ciliaris	
	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp
100 vs 200	ns	ns	ns	ns	ns	ns	*	ns	*	ns	*	ns	ns	ns
100+200 vs 400	*	*	ns	ns	ns	ns	*	ns	ns	ns	*	ns	ns	ns

Means within the same column followed by the same letter are not significantly different ($P > 0.05$).
* = significant at the 5 % probability level. ns = not significant ($P > 0.05$).

Table 5. Average plant density and herbage yield of seven perennial forage grasses measured the second growing season Sidi El Aydi).

Species	Plant density plants m^{-2})	Herbage yield (t DM ha^{-1})
Agropyron cristatum	10.0b	1.8c
A. elongatum	11.3a	5.3a
A. trichophorum	10.1b	2.9b
Elymus junceus	11.7a	1.8c
Phalaris tuberosa	8.1c	5.3a
Eragrostis curvula	3.4d	1.5c
Cenchrus ciliaris	0.2c	0.0d

#Means within the same column followed by the same letter are not significantly different (P > 0.05).

Table 6. Neutral detergent fiber and in-vitro dry matter digestibility of seven perennial forage grasses (Sidi El Aydi, 1987-88 experiment).

Species	Neutral detergent fiber		In-vitro dry matter digestibility	
	cut 1	cut 2	cut 1	cut 2
Agropyron cristatum	40.6	46.6	69.4	67.8
A. elllongatum	53.4	56.0	64.5	65.5
A. trrrichophorum	46.8	50.5	67.9	67.7
Elymuuus junceus	51.8	49.9	71.5	71.3
Phalaaaris tuberos	49.6	54.2	67.2	62.8
Eragrrrostis curvula	44.1	50.1	49.4	68.2
Cenchhhrus ciliaris	50.5	63.6	54.9	62.0

cut 1 corresponds to first cutting, cut 2 to second cutting

3. *Seeding date*

3.1 Stand establishment

There was a significant effect of seeding date ($P<0.05$) on species establishment, but this effect differed with year of planting ($P<0.05$). In the 1987-88 experiment, stand density did not differ between November and January plantings. Late seeding, however, reduced stand density (Table 7). In the 1988-89 experiment, stand density from November and January seedings were not statistically different ($P>0.05$) for *Agropyron trichophorum*, *Phalaris tuberosa*, *Cenchrus ciliaris* and *Eragrostis curvula*. This was not the case for *Agropyron cristatum*, *A. elongatum* and *Elymus junceus*. These species showed a significant increase in density between November and January seedings (Table 7). Apparently, precipitation patterns in 1988-89 were more favorable than those during the previous season. Late-planted seedings in the 1988-89 experiment coincided with more favorable precipitation sequence than did the 1987-88 seedings.

During the second growing season, effects of late seeding were still evident. In the 1987-88 experiment, all species exhibited a decrease in stand densities (Table 8). Cool-season species had average densities of 15, 13, and 5 plants m^{-2} from November, January, and February seedings, respectively. Stand densities were essentially the same for November and January seedings, but decreased significantly at the latest seeding. Warm-season species had the poorest stands (Table 8). Density of these species was highest from November seeding (5 plants m^{-2}).

A different picture was shown by the 1988-89 experiment (Table 8). Plant densities one year after planting were higher from January seeding. Average densities for cool-season species were 11, 14 and 11 plants m^{-2} for November, January, and March seedings. There was, however, no difference in stand density between November and January seedings for *Agropyron elongatum*, *A. trichophorum* and *Phalaris tuberosa*. Densities of *Agropyron cristatum* and *Elymus junceus* were significantly higher from late seeding. For warm- season species, *Cenchrus ciliaris* had better establishment from late seeding, whereas *Eragrostis curvula* established equally well from either November or January seedings.

3.2. Quantity and quality of herbage Produced

Plant species produced different amounts of herbage, and within species, production was significantly affected by seeding date ($P<0.05$). Each delay in seeding date decreased total herbage production (Table 9). For cool-season species, this reduction was not statistically significant between November and January seedings. Late seeding, however, reduced herbage production by an average of 68% in the 1987-88 experiment and by 27% in the 1988-89 experiment. *Agropyron trichophorum* was the only cool-season species that produced alike amounts of biomass regardless of seeding date in both experiments (Table 9).

Seeding date did not have much effect on nutritive value of grasses. Neutral detergent fiber (NDF) and in-vitro dry matter digestibility (IVDMD) were then averaged over seeding dates and are presented in Table 10. On average, cool-season species had lower NDF values than warm-season species. NDF values from the second cutting were higher because of advanced plant maturity. Averaged over species and seeding dates, NDF content of cool-season species was lowest at the first cutting (46%) and increased to about 56% at the second cutting. *Eragrostis curvula* had the highest NDF content (72%), and the lowest IVDMD values. Cool-season species had higher IVDMD than warm-season species (Table 10) and maintained high digestibilities over both cuttings, though *Phalaris tuberosa* matured earlier causing an IVDMD decline of 15 points between first and second cutting. Average IVDMD of cool-season species was 73% and 67% at the first and second cutting, respectively. Digestibilities of warm-season grasses did not exceed 61%.

Table 7. **Effect of seeding date on density (plants m^{-2}) at the end of first growing season of seven perennial forage grasses for 1987-88 (Exp1) and 1988-89 (Exp2) experiments at Jemaa Shaim.**

Planting year	1987-88			1988-89		
	Seeding date					
Species	Nov	Jan	Feb	Nov	Jan	Mar
Agropyron cristatum	39.1 ab	34.8 a	9.0 bc	18.0 bc	44.8 b	49.5 c
Agropyron elongatum	43.8 ab	35.7 a	26.2 a	36.2 ab	71.9 a	76.2 ab
Agropyron trichophorum	50.5 a	33.3 a	30.9 a	41.4 a	45.2 b	64.3 bc
Elymus junceus	26.7 ab	28.1 a	11.4 b	20.9 bc	73.3 a	58.5 bc
Phalaris tuberosa	39.5 ab	23.3 ab	4.8 bc	27.1 ab	31.9 c	93.8 a
Cenchrus ciliaris	14.8 ab	0.0 c	3.3 bc	1.4 c	16.2 d	8.6 d
Eragrostis curvula	10.0 b	9.1 bc	1.9 c	24.8 ab	31.0 c	7.1 d

Contrasts	Agropyron cristatum		Agropyron elongatum		Agropyron trichophorum		Elymus junceus		Phalaris tuberosa		Cenchrus ciliaris		Eragrostis curvula	
	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2
Nov vs Jan	ns	*	ns	*	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
Nov+Jan vs Feb	*	*	ns	*	ns	*	ns	ns	ns	*	ns	ns	ns	*

Means within a column followed by same letter are not significantly different ($P>0.05$).
* = significant at 5% probability level. ns = not significant ($P>0.05$).

Table 8. **Effect of seeding date on stand density (plants m^{-2}) one year after planting of seven perennial forage grasses for the 1987-88 (Exp1) and 1988-89 (Exp2) experiments (Jemaa Shaim).**

Planting year	1987-88			1988-89		
	Seeding date					
Species	Nov	Jan	Feb	Nov	Jan	Mar
Agropyron cristatum	15.3 a#	12.5 ab	0.8 c	8.1b	12.0bc	5.8cd
Agropyron elongatum	16.9 a	17.2 a	9.1 a	14.8a	15.3ab	16.3a
Agropyron trichophorum	15.5 a	14.8 a	8.8 a	14.1a	13.3bc	12.8b
Elymus junceus	16.1 a	13.7 ab	3.9 b	7.9b	16.7a	12.7b
Phalaris tuberosa	8.9 b	7.8 bc	0.8 c	8.9b	10.4cd	6.8c
Cenchrus ciliaris	4.4 b	0.6 d	1.2 c	0.4c	5.2e	2.6cd
Eragrostis curvula	4.7 b	1.6 cd	0.2 c	10.2ab	8.4de	0.6e

Contrasts	Agropyron cristatum		Agropyron elongatum		Agropyron trichophorum		Elymus junceus		Phalaris tuberosa		Cenchrus ciliaris		Eragrostis curvula	
	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2
Nov vs Jan	ns	*	ns	ns	ns	ns	ns	*	ns	ns	*	*	*	ns
Nov+Jan vs Feb	*	*	*	ns	ns	ns	*	ns	*	ns	ns	ns	*	*

Means within a column followed by same letter are not significantly different ($P > 0.05$).
* = significant at 5% probability level. ns = not significant ($P > 0.05$).

Table 9. Effect of seeding date on herbage production (t DM ha^{-1}) of seven perennial forage grasses for 1987-88 (Exp1) and 1988-89 (Exp2) experiments at Jemaa Shaim.

Planting year	1987-88			1988-89		
	Seeding dates					
Species	Nov	Jan	Feb	Nov	Jan	Feb
Agropyron cristatum	3.7 d	3.4 d	0.4 c	2.9d	3.0d	1.4d
Agropyron elongatum	13.2 b	10.0 b	5.6 a	11.2a	10.0a	8.7a
Agropyron trichophorum	6.5 c	6.3 c	4.1 ab	7.3bc	5.3bc	5.1bc
Elymus junceus	4.4 c	3.0 d	1.1 c	3.1d	3.8cd	2.0d
Phalaris tuberosa	16.8 a	15.4 a	2.9 abc	9.2ab	11.2a	7.3ab
Cenchrus ciliaris	3.8 d	0.4 e	1.2 bc	6.1c	6.0b	0.4d
Eragrostis curvula	5.1 c	2.3 de	0.2 c	0.5d	4.8bcd	2.7cd

Contrasts	Agropyron cristatum		Agropyron elongatum		Agropyron trichophorum		Elymus junceus		Phalaris tuberosa		Cenchrus ciliaris		Eragrostis curvula	
	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2
Nov vs Jan	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	*	*
Nov+Jan vs Feb	*	*	*	ns	ns	ns	*	ns	*	ns	*	*	ns	ns

Means within a column followed by same letter are not significantly different ($P>0.05$).
* = significant at 5 % probability level. ns = not significant (P<0.05).

Table 10. Neutral detergent fiber (NDF) and in-vitro dry matter digestibility of seven perennial forage grasses (Jemaa Shaim, 1987-88).

Species	Neutral detergent fiber		In-vitro dry matter digestibility	
	cut 1	cut 2	cut 1	cut 2
Agropyron cristatum	46.5	50.1	72.0	68.9
A. elllongatum	43.3	59.2	73.8	68.5
A. trrrichophorum	42.6	53.2	72.2	71.5
Elymuuus junceus	48.7	58.9	74.4	68.5
Phalaaaris tuberos	46.8	59.6	74.7	58.9
Eragrrrostis curvula	51.7	58.6	58.4	62.6
Cenchhhrus ciliaris	68.9	74.8	61.6	62.2

Cut 1 corresponds to first cutting, cut 2 to second cutting

CONCLUSIONS

The present study has shown that perennial grasses can establish under dryland conditions of Morocco. They start growth early in the season, and stay green late into the summer months. Farmers in the semi-arid areas of Morocco, however, are not accustomed to cultivating these species. It is then paramount that the best combination of cultural techniques be applied when seeding perennial grasses. In this study, three aspects of these techniques were investigated. The following conclusions are drawn with respect to seeding *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, *Phalaris tuberosa*, *Cenchrus ciliaris*, and *Eragrostis curvula* at three depths, rates, and dates in two semi-arid areas of Morocco.

Seeding depth

In this study, maximum planting depth was 1 cm for *Agropyron cristatum*, *A. elongatum*, *A. trichophorum*, *Elymus junceus*, and *Eragrostis curvula*. *Phalaris tuberosa* may be seeded at depths between 1 and 4 cm.

Seeding rate

Seeding rates from 100 to 400 PLS m^{-2} will produce satisfactory stands. Increasing seeding rate from 100 to 400 PLS m^{-2} affected neither quantity nor quality of herbage produced. A seeding rate of 100 PLS m^{-2} is adequate to produce a satisfactory grass stand on well-prepared seedbed with adequate weed control. If one of these conditions is not satisfied, then a seeding rate of 200 PLS m^{-2} may be more appropriate.

Seeding date

The species tested in this study may be seeded over a period of 2 months: November through early January. Planting, however, should be delayed till weeds emerge around late December. Weeds will then be easily controlled through cultivation before planting.

Perennial grasses are very sensitive to weed competition. It is of utmost importance that weeds be controlled prior to planting and at least once when perennial grasses are at the three-leaf stage.

Phalaris tuberosa and *Agropyron elongatum* were outstanding with respect to establishment and productivity. These species should be considered in revegetation programs of semi-arid areas of Morocco.

REFERENCES

Arif, A., Stubbendieck, J., Waller, S. and Stroup, W. (1989). Introduction and evaluation of perennial forage grasses for use in dryland farming regions of Morocco. Proc. of the XVI International Grassland Congress, Nice, France. p.1603-4.

Harper, F.L. (1977). Population biology of plants. Academic Press, London.

Heady, H.F. (1975). Rangeland management. McGraw-Hill Book Company, New York.

Hoen, K. (1968). The effect of plant size and developmental stage on summer survival of some perennial grasses. *Aust. J. Exp. Agric. Anim. Husb.* **8**:190-6.

Schwendiman, J.L., and Hawk, V.B. (1978). Other grasses for the North and West. *In* "Forages: the science of grassland agriculture. 4th ed" (M.E. Heath, R.F. Barnes, and D.S. Metcalfe, eds.). p. 231-42. The Iowa State Univ. Press, Ames, Iowa, U.S.A.

Soltanpour, P.N., Azzaoui, A., El Gharous, M.A. and Abdelmonem, M. (1987). Nitrogen and phosphorus soil test calibration studies in the Chaouia. INRA/MIAC-CRRAC, B.P. 290. Settat, Morocco.

Steel, R.G.D., and Torrie, J.H. (1980). Principles and procedures of statistics. McGraw Hill Book Co. New York.

Tilley, J.M., and Terry, R.A. (1963). A two-stage technique for the in vitro digestion of forage crops. *J. Brit. Grassl. Soc.* **18**, 104-11.