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Effect of harvesting time on seed weight *per se* and seed quality in indigenous rangeland and forage grass species

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Abstract: Two indigenous rangeland species, *Cenchrus ciliaris* L. and *Coelachyrum piercei* L.were investigated with *Chloris gayana* L. under Arabian Peninsula Research Program (APRP) of ICARDA (International Center for Agricultural Research in the Dry Areas) to know the effect of harvesting time on seed weight (husked) *per se* and quality from November 2002 to May 2004 spanning seven harvests in two different locations (Livestock Research Center (LRC), Rumais in the Batinah region and Agriculture Research Station (JRS), Jimah in the Interior region) of Oman. At each harvest, inflorescences were collected at physiological maturity (PM), one week after PM (1WAPM), two weeks after PM (2WAPM) and three weeks after PM (1WAPM). In all the grass species there was gradual and significant decrease ($p<0.05$) in seed weight/inflorescence from physiological maturity (PM) to subsequent harvesting times with significant increase (improvement) ($p<0.05$) in germination % from PM to 1WAPM or 2 WAPM and then decrease at 3WAPM. Interaction effect of harvests x harvesting times was highly significant ($p<0.01$) in all the grass species. At LRC and JRS, germination % was significantly higher ($p<0.05$) at 2WAPM (55.67 to 69 %) than that at preceding and succeeding times with significant loss of seed weight/ inflorescence (5 to >10%) during November and February when fairly cool temperature and low humidity exist. May or summer figures showed differential response of grass species in producing good quality seeds at LRC (hot and humid) and JRS (hot and dry). The results indicated that these grass species could be harvested within couple of weeks after physiological maturity for optimum high quality seed yield in Oman.

Key words : Seed, harvest, time, rangeland, grasses

Introduction

Many of the tropical indigenous grass species are relatively wild which have not been domesticated and rigorously selected for good seed production characteristics because of which many problems have been encountered in the seed multiplication tasks in these species. The major problem is that seeds in the grass species do not mature at one time, hence it is difficult to judge when the rate of increase of ripe seeds from new inflorescences just balance the loss of high quality seed from older inflorescences (Humphreys, 1978; Berdahl and Frank, 1998). Moisture content falls quite rapidly after full development of seed, which affects the overall viability of harvested seeds (Bennett and Marchbanks, 1969). Another problem that confronts grass seed growers is the readiness of most tropical pasture seed to abscissa or to detach themselves shortly after reaching maturity. This prevents the amassing on the crop of the successfully ripened seeds. For instance, *Cenchrus ciliaris cv. Moloppo* will retain ripe seed for only six to eight days (Skerman and Riveros, 1989). Rangeland grass or pasture species are neglected material for investigation especially on agronomic or physiological aspects of seed production from the fact that only few (2-3) relevant references are available. In these studies no systematic approach of finding of time of harvest for seed in grass species is followed. Conclusions were drawn based on their observations on different dates of harvest. It is known fact that as grass species have been evolved as perennials for vegetative forage yield, they have very low seed productivity (Chatterjee and Das, 1989; Boonman, 1972). As such, the productivity and availability of seeds in the inflorescence per se at harvest have been observed to be important factors in the seed production of any grass species (Chatterjee and Das, 1989; Loch and Clark, 2000). In light of the above, the investigations were conducted in two locations (Livestock Research Center (LRC), Rumais in the Batinah region and Agriculture Research Station (JRS), Jimah in the Interior region) from November 2002 to May 2004 under Arabian Peninsula Research Program (APRP) of ICARDA (International Center for Agricultural Research in the Dry Areas)- Phase -II (2001-2005) to know the effect of harvesting time on seed weight per se and seed quality and establishing optimum time of maturity in the indigenous rangeland and forage grass species. This paper discusses results of the investigations spanning seven harvesting times.

Material and methods

The material under study included two indigenous rangeland forage species viz. Buffel grass-*Cenchrus ciliaris* L. (UAE) and *Coelachyrum piercei* L. (UAE) collected under ICARDA-APRP Phase–I (2001-2005) (Peacock *et al.*, 2000) and Rhodes grass (*Chloris gayana* Kunth.)- Katambora, which were investigated in our another experiment laid under drips for seed

production respectively during winter, 2001 and summer, 2002 at two locations namely Livestock Research Center, Rumais (LRC) in the Batinah region and Agriculture Research Station, Jimah (JRS) in the Interior region till December 2004. LRC and JRS are located in the regions, which are diverse in climatic conditions throughout the year as indicated by the meteorological data (Table 1 and 2).

The present investigations were conducted from November 2002 to May 2004. At each harvest, forty inflorescences that had attained the stage of physiological maturity were randomly selected in each grass species and tagged by the white labels. The stage of physiological maturity (PM) was identified by senescence or drying of rachis of the inflorescence when mainly whole axis from the base of the rachis turns either straw colored or brittle or both). Ten tagged inflorescences in each grass species were collected at each of four harvesting times viz. at physiological maturity stage (At PM), one week after physiological maturity (1WAPM), two weeks after physiological maturity (2WAPM) and three weeks after physiological maturity (3WAPM) (Plates 1 -3). These inflorescences were dried under shade for about two weeks when they were found to possess about 10-12% moisture %. The observations on weight of inflorescence (mg), seed weight (with husk)/ inflorescence (mg), seed recovery (%) from inflorescence and germination % (tested after four to five months, as there was very less germination (0-1.5 %) immediately (one week) after harvest) were recorded. The seeds of samples had been subjected for laboratory germination test with five replications following the procedure suggested by Agrawal (1980) using Top of Paper (TP) method of germination.

The experimental data of each location on above traits were subjected to ANOVA separately (as the crops of the two locations were of different age), considering harvests, grass species and harvesting times as factors in CRD using MSTAT-C computer program (Gomez and Gomez, 1984).

Results and discussion

The results of the investigations in two locations viz. LRC and JRS indicated the existence of differential expression of the seed related traits in three grass species studied at different harvesting times in different harvests (Tables 3 to 6). Comparisons of results of the two locations made in this report are just are based on factual data for understanding the trend in behavior of the grass species at different stages of maturity, but are not statistical. The combined analysis of data has not been carried out because of differential age of the crops of the two locations.

Inflorescence weight (mg) : In respect of inflorescence weight, the effects of all main factors and effects of their two 2- factor interactions viz. harvests x grass species and grass species x harvesting times were highly significant ($p<0.05$) in both the locations (Tables 3 (a) and (b)). The grass species behaved differentially in the formation of inflorescence in the two locations. In both the locations, Cenchrus ciliaris (238.35 mg at LRC and 240.31 mg at JRS) recorded significantly highest ($p<0.05$) mean inflorescence weight over harvesting times followed by Chloris gayana (192.19 mg at LRC and 200.13 mg at JRS) and Coelachyrum piercei (108.72 mg at LRC and 110.96 mg at JRS).

In both the locations, inflorescence weight of different harvests was not significant in respect of either Cenchrus ciliaris (208.64 to 262.87 mg at LRC and 192.97 to 261.10 mg at JRS) or in Coelachyrum piercei (90.37 to 123.73 mg at LRC and 87.29 to 134.15 mg at JRS) and Chloris gayana (148.95 to 234.49 mg at LRC and 142.60 to 244.32 mg at JRS).

Table 1. The meteorological data of live stock research center, Rumais in the Batinah

Sl. No.	Year	Average of 1995 - 2001			
		Max.	Min.	R.H	Sunshine
Month		T (C°)	T (C°)	(%)	(hrs)
1	Jan.	25.2	15.7	66.3	8.6
2	Feb.	26.4	16.9	63.1	9.3
3	Mar.	28.7	19.1	63.3	9.5
4	Apr.	35.0	22.8	52.5	10.6
5	May	39.7	27.8	45.5	11.4
6	Jun.	39.6	28.8	55.9	11.5
7	Jul.	38.2	29.3	56.8	11.0
8	Aug.	36.7	28.3	63.8	10.7
9	Sep.	35.8	26.1	60.6	10.0
10	Oct.	34.5	23.1	58.8	9.7
11	Nov.	30.0	19.6	66.2	9.3
12	Dec.	27.7	18.3	60.5	8.9

* Rumais Meteorological Station (Latitude- 23o40/ N, Longitude- 58E and Altitude- 24m above msl)

In all the grass species there was gradual decrease in inflorescence weight from physiological maturity (PM) to the subsequent harvesting times. In respect of Cenchrus ciliaris, the decrease in inflorescence weight was significant ($p<0.05$) from PM (267.15 mg) to 1WAPM (258.26 mg), 2WAPM (220.10 mg) and 3WAPM (207.87 mg) at LRC. However, at JRS, the decline in inflorescence weight was although gradual but not significant only between PM (266.74 mg) and 1WAPM (260.53 mg). Similarly, in case of Chloris gayana, decrease in the weight of the inflorescence was significant ($p< 0.05$) from first (PM, 218.29 mg at LRC; 227.69 mg) to the last (3WAPM, 163.43 mg at LRC; 169.11 mg at JRS) time of harvest in both the locations. In case of Coelachyrum piercei, however, decrease between the inflorescence weights of 1WAPM (110.17 mg at LRC and 113.04 mg at JRS) and 2WAPM (106.08 mg at LRC and 110.28 mg at JRS) was only not significant ($p>0.05$).

'**Seed recovery from inflorescence (%) :** In respect of seed recovery from inflorescence, effects of all the main factors viz. harvests, grass species and harvesting times and effects of their interactions were highly significant ($p<0.01$) at JRS while at LRC, effects of all the factors except that of interaction between grass species and harvesting times, were highly significant ($p<0.01$) (Tables 5 (a) and (b)). The grass species behaved differentially in respect of seed recovery (%) in the two locations. Just like in seed weight, in both the locations, Cenchrus ciliaris (76.64% at LRC and 78.21 % at JRS) recorded significantly highest ($p<0.05$) mean seed recovery over harvests followed by Chloris gayana (60.76 % at LRC and 59.30 % at JRS) and Coelachyrum piercei (45.07 % at LRC and 46.26 % at JRS).

In all the grass species there was gradual and significant ($p<0.05$) decrease in the seed recovery from physiological maturity (PM) to the subsequent harvesting times in both the locations. In case of Cenchrus ciliaris, the decrease was from 80.90 % (PM) to 72.65% (3WAPM) at LRC and from 81.70 % (PM) to 74.27 % (3WAPM) at JRS while in Chloris gayana it was from 65.30 % (PM) to 56.52 % (3WAPM) at LRC and from 64.56 % (PM) to 55.19 % (3WAPM) at JRS and in Coelachyrum piercei, the decrease was from 48.63 % (PM) to 41.37 % (3WAPM) at LRC and from 48.34 % (PM) to 43.29 % (3WAPM) at JRS. Such decrease in seed recovery in subsequent harvesting times has been mostly attributed to shattering of seeds from the inflorescences in all the grass species (see plates 1-3). Shattering of the seeds has been one of the major problems that confronts grass seed growers (Nadaf et al, 2004). Lloyd (1970) reported that 25 % of the panicle length had shed its seeds within two weeks in Panicum coloratum.

Germination % : Germination % of the seed represents its quality and magnitude of viability - thus seed with high germination % is of better quality than that with low germination % (Van Gastel et al, 1996). In respect of germination %, the effects of harvests, harvesting times and effect of their interaction were highly significant ($p<0.01$) in both the locations (Tables 6 (a) and (b)). The interaction effect of harvests x grass species and that of grass species x harvesting times, were significant ($p<0.05$) only at JRS and ARC, respectively. The grass species behaved differentially with respect to germination (%) in the two locations at different times of harvest in different harvesting times. At LRC, mean germination % among different harvests, varied from 48.83 to 54.67 %, from 46.83 to 54.00% and from 45.75 to 53.25 % in respect of Cenchrus ciliaris, Coelachyrum piercei and Chloris gayana, respectively. Interestingly, germination % of seed lots of harvests taken during November and February showed significantly ($p<0.05$) higher germination % in both the years at LRC but not at JRS.

In respect of germination % of different harvesting times in Cenchrus ciliaris, there was gradual and significant ($p<0.05$) increase in germination % from PM (40.81 %) to 2WAPM (58.57 %) and then it dropped significantly to 50.38% at 3WAPM at LRC but in JRS, germination % was found significantly increased ($p<0.05$) from PM (42.05 %) to 2WAPM (51.24 %),

Table 2. The meteorological data of Agriculture Research Station, Jimah in the Interior

Sl. No.	Year	Average of 1997 - 1998			
		Max.	Min.	R.H	Sunshine
Month		T (C^o)	T (C^o)	(%)	(hrs)
1	Jan.	22.5	12.8	62.3	8.1
2	Feb.	27.3	14.8	47.9	9.0
3	Mar.	29.6	17.9	46.5	9.9
4	Apr.	34.1	20.5	38.6	10.6
5	May	40.0	25.0	24.2	10.6
6	Jun.	42.3	28.3	30.5	10.8
7	Jul.	42.4	28.4	33.4	10.5
8	Aug.	41.4	27.6	39.9	10.3
9	Sep.	39.5	25.2	36.5	10.2
10	Oct.	35.5	21.9	34.8	10.2
11	Nov.	30.2	17.9	42.8	8.7
12	Dec.	25.6	14.8	55.0	7.2

* Jimah Meteorological Station (Latitude- 22o28'/ N, Longitude- 57o9'E and Altitude-700 m above msl)

Plate 1. Different stages of maturity in *Cenchrus ciliaris* L.

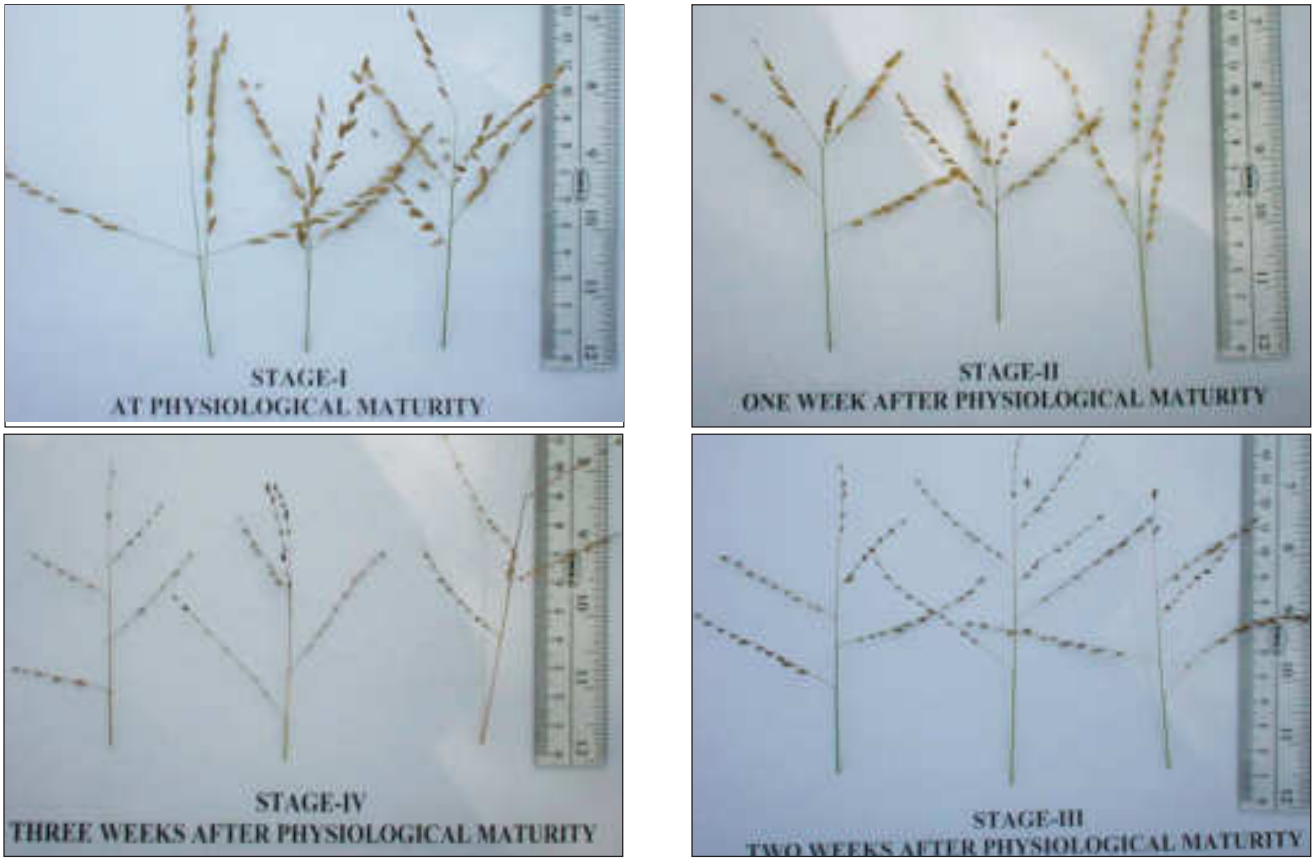

Plate 2. Different stages of maturity in *Coelachyrum piercei* L.

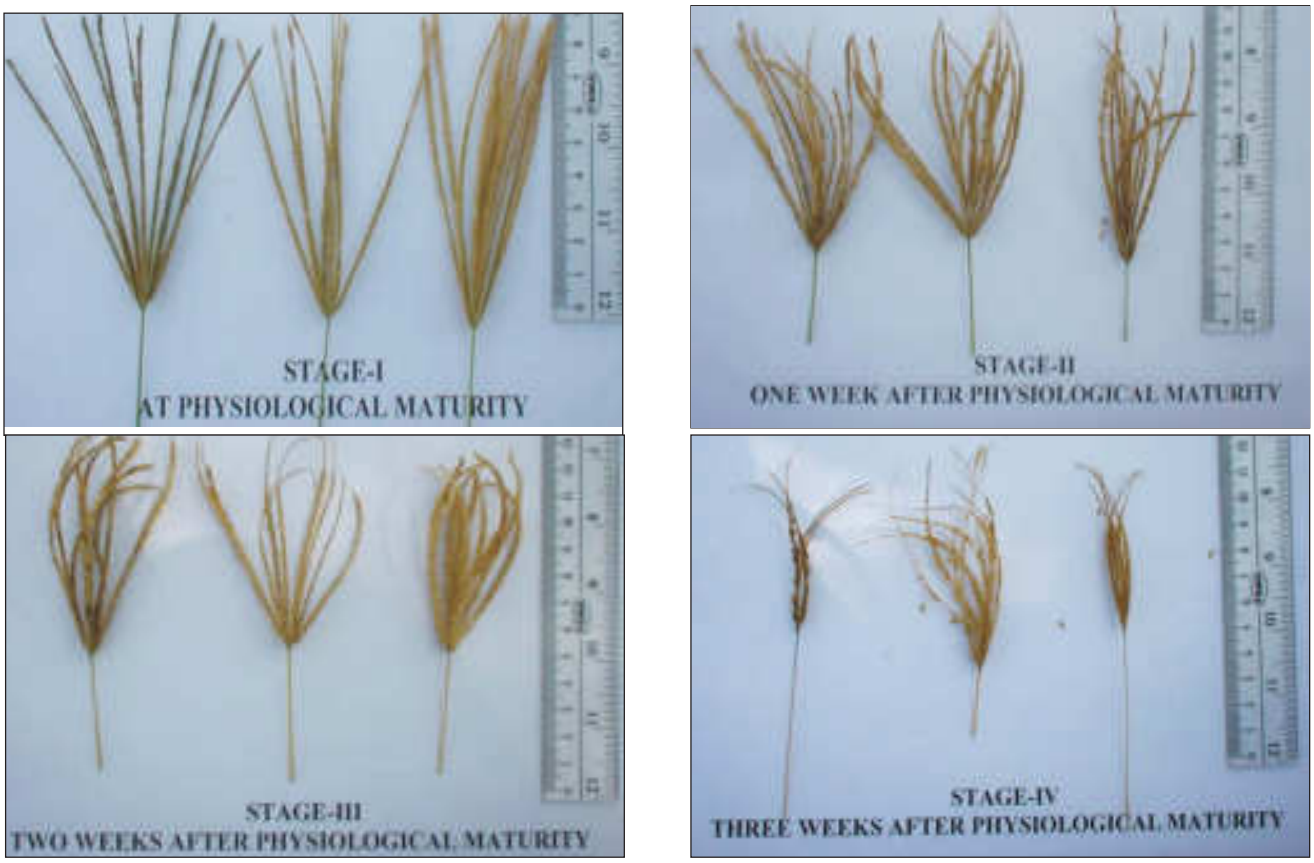

Plate 3. Different stages of maturity in *Chloris gayana L.*

Table 3 (a). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at LRC, Rumais

Sl. No.	Grass Species	Harvests	Inflorescence weight (mg)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris* L	H1 (Nov '02)	277.00	275.20	232.80	228.23	253.31
		H2 (Feb '03)	266.67	251.60	221.13	205.60	236.25
		H3 (May '03)	289.67	285.33	241.20	235.27	262.87
		H4 (Aug'03)	276.17	253.00	218.67	195.73	235.89
		H5 (Nov '03)	272.17	266.17	222.67	216.23	244.31
		H6 (Feb '04)	258.83	239.43	213.53	196.83	227.16
		H7 (May '04)	229.57	237.10	190.73	177.17	208.64
		Mean	267.15	258.26	220.10	207.87	238.35
2	*Coelachyrum piercei* L.	H1 (Nov '02)	137.60	111.00	112.80	88.00	112.35
		H2 (Feb '03)	120.40	115.63	110.10	96.30	110.61
		H3 (May '03)	142.47	114.53	116.87	92.03	116.48
		H4 (Aug'03)	137.70	132.67	119.33	105.20	123.73
		H5 (Nov '03)	136.53	106.73	98.77	87.13	107.29
		H6 (Feb '04)	114.47	102.97	96.33	87.23	100.25
		H7 (May '04)	114.17	87.67	88.33	71.30	90.37
		Mean	129.05	110.17	106.08	89.60	108.72
3	*Chloris gayana* L.	H1 (Nov '02)	232.87	208.00	191.77	167.43	200.02
		H2 (Feb '03)	259.57	256.70	225.47	196.23	234.49
		H3 (May '03)	225.13	197.97	183.83	160.30	191.81
		H4 (Aug'03)	204.03	195.17	176.33	164.17	184.93
		H5 (Nov '03)	213.00	196.00	183.33	166.33	189.67
		H6 (Feb '04)	220.67	210.33	186.33	164.60	195.48
		H7 (May '04)	172.77	154.40	143.67	124.97	148.95
		Mean	218.29	202.65	184.39	163.43	192.19

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	5.36
Grass species	**	3.51
Harvests x Grass species	**	9.28
Harvesting time	**	4.05
Harvest x Harvesting time	NS	--
Grass species x Harvesting time	**	7.01
Harvests x Harvesting time x Grass species	NS	-
CV (%)	6.45	

Table 3(b). Means of inflorescence weight of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at JRS, Jimah

Sl. No.	Grass Species	Harvests	Inflorescence weight (mg)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Enchrus ciliaris L*	H1 (Nov '02)	286.07	282.87	240.33	235.13	261.10
		H2 (Feb '03)	272.57	262.00	230.80	212.23	244.40
		H3 (May '03)	276.23	270.93	231.60	225.07	250.96
		H4 (Aug'03)	286.03	284.80	227.00	208.43	251.57
		H5 (Nov '03)	271.93	266.33	229.13	222.43	247.46
		H6 (Feb '04)	258.83	252.77	221.30	202.00	233.73
		H7 (May '04)	215.50	204.00	180.43	171.93	192.97
		Mean	266.74	260.53	222.94	211.03	240.31
2	*Coelachyrum piercei L.*	H1 (Nov '02)	141.30	114.57	118.93	91.07	116.47
		H2 (Feb '03)	128.47	119.57	111.17	100.10	114.83
		H3 (May '03)	136.83	111.70	111.83	88.40	112.19
		H4 (Aug'03)	145.60	144.80	133.40	112.80	134.15
		H5 (Nov '03)	133.30	103.47	108.27	81.70	106.69
		H6 (Feb '04)	122.00	110.07	101.00	87.33	105.10
		H7 (May '04)	106.37	87.10	87.37	68.30	87.29
		Mean	130.55	113.04	110.28	89.96	110.96
3	*Chloris gayana L.*	H1 (Nov '02)	239.07	215.40	196.60	165.87	204.24
		H2 (Feb '03)	269.87	266.53	234.30	206.57	244.32
		H3 (May '03)	216.93	189.23	175.23	154.20	183.90
		H4 (Aug'03)	212.80	204.80	188.40	175.60	195.40
		H5 (Nov '03)	227.33	206.67	193.17	166.80	198.49
		H6 (Feb '04)	258.67	256.00	217.00	196.33	232.00
		H7 (May '04)	169.17	147.57	135.27	118.37	142.60
		Mean	227.69	212.31	191.42	169.11	200.13

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	6.98
Grass species	**	4.58
Harvests x Grass species	**	12.11
Harvesting time	**	5.28
Harvests x Harvesting time	NS	-
Grass species x Harvesting time	**	9.15
Harvests x Harvesting time x Grass species	NS	-
CV (%)	8.23	

which then dropped significantly at 3WAPM (42.19 %). Increase in germination % from 1WAPM to 2WAPM was however, not significant ($p>0.05$). Other two grass species viz. Coelachyrum piercei and Chloris gayana had almost similar trend in germination % of different harvesting times as noticed in case of Cenchrus ciliaris in both the locations (Tables 6 (a) and (b)).

Interaction effect of harvests and harvesting times was very much apparent and significant in all the grass species and is subject of our concern (Tables 6 (a) and (b)). At LRC and JRS, it was observed that in November and February that represent winter when fairly cool temperature and low humidity exist, germination % was significantly higher ($p<0.05$) at 2WAPM (55.67 to 69.00 %) than that at preceding and succeeding harvesting times in all the three grass species studied. This indicated that good quality seed could be harvested at this time but the loss of seed weight/ inflorescence from 1WAPM was found to be from 5 to > 10% and significant in the grass species studied viz. Cenchrus ciliaris, Coelachyrum piercei and Chloris gayana (Tables 6 (a) and (b)). May or summer figures, on the other hand, were still quite interesting as the grass species had differential behavior in producing good quality seeds at the climates of LRC (hot and humid) and JRS (hot and dry) (Tables 6 (a) and (b)). In May, germination % was significantly higher ($p<0.05$) at 1WAPM (52.33 to 60.33 %) than that at preceding and succeeding harvesting times, in general, in all the grass species and declined significantly in succeeding harvesting times. At LRC, germination % recorded at 3WAPM was 42.00 to 46.00 % but at JRS, it was up to 35.00 to 39.00 % (Tables 6 (a) and (b)). This indicated that in summer seed deterioration was fast at JRS probably because of hot dry weather than that at LRC characterized by hot and humid weathers (Tables 1 and 2; Tables 6 (a) and (b)).

Grass seed growers often face substantial loss of good quality (viable) seeds while harvesting due to lack of knowledge about the appropriate harvesting time. It has been observed that some tropical grass species may produce good yields of seeds to the extent of 1000 kg/ha and above, but only a few proportion (may be 5-7% in Setaria anceps) is commercially recoverable (Chatterjee and Das, 1989). Reduction in seed weight from PM onwards is due to many reasons of which these two are of significance- i. rapid loss of moisture content after full development of seed and ii. shattering of seeds depending up on wind blows shortly after reaching maturity. Brzostowski and Owen (1966) found that seeds of Cenchrus ciliaris harvested at Kongwa, Tanzania, at the milky, cheesy and hard stages of seed, showed 83, 85 and 87 per cent viability after five months of

Table 4(a). Means of seed weight / inflorescence of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at LRC, Rumais

Sl. No.	Grass Species	Harvests	Seed weight/inflorescence (mg)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	223.10	214.23	176.20	171.27	196.20
		H2 (Feb '03)	216.77	197.27	164.83	151.73	182.65
		H3 (May '03)	238.47	226.53	186.43	178.00	207.36
		H4 (Aug'03)	276.17	253.00	218.67	195.73	235.89
		H5 (Nov '03)	272.17	266.17	222.67	216.23	244.31
		H6 (Feb '04)	258.83	239.43	213.53	196.83	227.16
		H7 (May '04)	229.57	237.10	190.73	177.17	208.64
		Mean	245.01	233.39	196.15	183.85	214.60
2	*Coelachyrum piercei L.*	H1 (Nov '02)	68.90	52.90	52.43	37.53	52.94
		H2 (Feb '03)	59.87	54.10	48.70	40.77	50.86
		H3 (May '03)	71.77	54.57	52.93	40.20	54.87
		H4 (Aug'03)	137.70	132.67	119.33	105.20	123.73
		H5 (Nov '03)	136.53	106.73	98.77	87.13	107.29
		H6 (Feb '04)	114.47	102.97	96.33	87.23	100.25
		H7 (May '04)	114.17	87.67	88.33	71.30	90.37
		Mean	100.49	84.52	79.55	67.05	82.90
3	*Chloris gayana L.*	H1 (Nov '02)	154.07	129.03	115.03	98.17	124.08
		H2 (Feb '03)	170.63	160.70	136.10	108.57	144.00
		H3 (May '03)	143.93	122.43	109.07	93.03	117.12
		H4 (Aug'03)	204.03	195.17	176.33	164.17	184.93
		H5 (Nov '03)	213.00	196.00	183.33	166.33	189.67
		H6 (Feb '04)	220.67	210.33	186.33	164.60	195.48
		H7 (May '04)	172.77	154.40	143.67	124.97	148.95
		Mean	182.73	166.87	149.98	131.41	157.75

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	3.94
Grass species	**	2.58
Harvests x Grass species	**	6.84
Harvesting time	**	2.98
Harvests x Harvesting time	NS	
Grass species x Harvesting time	**	5.17
Harvests x Harvesting time x Grass species	NS	-
CV (%)	7.32	-

Table 4(b). Means of seed weight / inflorescence of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at JRS, Jimah

Sl. No.	Grass Species	Harvests	Seed weight/inflorescence (mg)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	233.53	225.30	185.43	177.73	205.50
		H2 (Feb '03)	226.40	210.27	179.00	159.63	193.83
		H3 (May '03)	228.33	214.13	179.73	170.40	198.15
		H4 (Aug'03)	227.97	228.77	176.10	156.37	197.30
		H5 (Nov '03)	219.03	210.00	173.73	159.57	190.58
		H6 (Feb '04)	211.93	202.13	166.33	140.33	180.18
		H7 (May '04)	178.10	166.37	139.37	132.53	154.09
		Mean	217.90	208.14	171.38	156.65	188.52
2	*Coelachyrum piercei L.*	H1 (Nov '02)	72.40	55.10	54.63	39.93	55.52
		H2 (Feb '03)	64.77	56.20	51.23	44.67	54.22
		H3 (May '03)	68.87	52.83	53.47	38.03	53.30
		H4 (Aug'03)	71.97	66.90	56.70	44.80	60.09
		H5 (Nov '03)	66.47	46.33	43.40	38.40	48.65
		H6 (Feb '04)	54.17	46.50	42.33	37.77	45.19
		H7 (May '04)	45.83	40.60	57.43	28.43	43.07
		Mean	63.50	52.07	51.31	38.86	51.43
3	*Chloris gayana L.*	H1 (Nov '02)	155.67	134.47	115.90	96.37	125.60
		H2 (Feb '03)	178.97	168.90	145.17	121.07	153.53
		H3 (May '03)	141.57	116.10	104.57	89.07	112.83
		H4 (Aug'03)	136.23	124.20	108.60	98.80	116.96
		H5 (Nov '03)	147.23	120.33	103.33	76.60	111.87
		H6 (Feb '04)	161.00	138.67	110.17	101.50	127.84
		H7 (May '04)	108.30	88.73	80.50	68.33	86.47
		Mean	147.00	127.34	109.75	93.11	119.30

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	4.93
Grass species	**	3.23
Harvests x Grass species	**	8.54
Harvesting time	**	3.73
Grass species x Harvesting time	**	6.45
Harvests x Harvesting time	NS	-
Harvests x Harvesting time x Grass species	NS	-
CV (%)	8.91	-

Table 5 (a). Means of seed recovery from inflorescence of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at LRC, Rumais

Sl. No.	Grass Species	Harvests	Seed Recovery from inflorescence (%)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	80.65	77.81	75.70	75.00	77.29
		H2 (Feb '03)	81.33	78.39	74.50	73.83	77.01
		H3 (May '03)	82.31	79.32	77.33	75.66	78.66
		H4 (Aug'03)	82.66	80.65	78.98	75.63	79.48
		H5 (Nov '03)	80.08	77.92	74.62	66.64	74.82
		H6 (Feb '04)	80.30	73.49	67.12	64.38	71.32
		H7 (May '04)	78.95	77.80	77.46	77.40	77.90
		Mean	80.90	77.91	75.10	72.65	76.64
2	*Coelachyrum piercei L.*	H1 (Nov '02)	49.99	47.65	46.50	42.68	46.71
		H2 (Feb '03)	49.65	46.81	44.26	42.33	45.76
		H3 (May '03)	50.33	47.64	45.31	43.81	46.77
		H4 (Aug'03)	49.26	39.62	43.82	35.79	42.12
		H5 (Nov '03)	50.60	44.88	44.74	40.99	45.30
		H6 (Feb '04)	40.59	43.53	40.51	40.33	41.24
		H7 (May '04)	49.98	49.04	47.78	43.67	47.62
		Mean	48.63	45.60	44.70	41.37	45.07
3	*Chloris gayana L.*	H1 (Nov '02)	66.16	62.00	59.98	58.66	61.70
		H2 (Feb '03)	65.76	62.62	60.31	55.34	61.01
		H3 (May '03)	63.99	61.82	59.32	57.99	60.78
		H4 (Aug'03)	72.46	63.87	62.86	57.39	64.15
		H5 (Nov '03)	61.55	58.98	55.41	51.93	56.97
		H6 (Feb '04)	60.67	62.83	58.11	56.32	59.48
		H7 (May '04)	66.51	61.75	58.68	58.03	61.24
		Mean	65.30	61.98	59.24	56.52	60.76
	Statistical Parameters:		F-Test		LSD (5%)		
	Harvests		**		1.24		
	Grass species		**		0.81		
	Harvests x Grass species		**		2.14		
	Harvesting time		**		0.93		
	Harvests x Harvesting time		*		2.47		
	Grass species x Harvesting time		NS		-		
	Harvests x Harvesting time x Grass species		*		4.28		
	CV (%)		4.40				

Table 5 (b). Means of seed recovery from inflorescence of two indigenousrangeland forage grass species and rhodes grass in four harvesting times and seven harvests at JRS, Jimah

Sl. No.	Grass Species	Harvests	Seed Recovery from inflorescence (%)				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	81.65	79.66	77.16	75.59	78.52
		H2 (Feb '03)	82.99	80.33	77.50	75.17	79.00
		H3 (May '03)	82.65	78.99	77.67	75.65	78.74
		H4 (Aug'03)	79.65	80.33	77.65	74.98	78.15
		H5 (Nov '03)	80.49	78.87	75.85	71.81	76.76
		H6 (Feb '04)	81.83	80.13	74.98	69.61	76.64
		H7 (May '04)	82.64	81.63	77.29	77.05	79.65
		Mean	81.70	79.99	76.87	74.27	78.21
2	*Coelachyrum piercei L.*	H1 (Nov '02)	51.30	48.13	45.94	43.85	47.31
		H2 (Feb '03)	50.47	46.96	46.08	44.60	47.03
		H3 (May '03)	50.30	47.31	47.97	42.97	47.14
		H4 (Aug'03)	49.37	46.28	42.49	39.68	44.46
		H5 (Nov '03)	49.86	44.82	40.12	46.98	45.45
		H6 (Feb '04)	44.41	42.37	41.84	43.34	42.99
		H7 (May '04)	42.69	46.58	66.84	41.64	49.44
		Mean	48.34	46.06	47.33	43.29	46.26
3	*Chloris gayana L.*	H1 (Nov '02)	65.15	62.39	58.99	58.17	61.18
		H2 (Feb '03)	66.34	63.32	61.97	58.64	62.57
		H3 (May '03)	65.33	61.35	59.65	57.74	61.02
		H4 (Aug'03)	63.99	60.68	57.65	56.32	59.66
		H5 (Nov '03)	64.77	58.19	53.48	46.04	55.62
		H6 (Feb '04)	62.25	54.18	50.75	51.69	54.72
		H7 (May '04)	64.09	60.11	59.50	57.74	60.36
		Mean	64.56	60.03	57.43	55.19	59.30
Statistical Parameters			F-Test		LSD (5%)		
	Harvests		**		1.25		
	Grass species		**		0.82		
	Harvests x Grass species		**		2.17		
	Harvesting time		**		0.95		
	Harvests x Harvesting time		**		2.51		
	Grass species x Harvesting time		**		1.64		
	Harvests x Harvesting time x		**		4.35		
	CV (%)		4.43				

Table 6 (a). Means of germination of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at LRC, Rumais

Sl. No.	Grass Species	Harvests	Germination %				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	42.00	51.33	65.67	59.67	54.67
		H2 (Feb '03)	42.00	48.00	69.00	58.33	54.33
		H3 (May '03)	40.33	60.00	51.67	43.33	48.83
		H4 (Aug'03)	41.33	61.67	52.67	42.33	49.50
		H5 (Nov '03)	39.67	47.33	55.67	49.67	48.09
		H6 (Feb '04)	38.67	47.00	62.00	53.33	50.25
		H7 (May '04)	41.67	60.67	53.33	46.00	50.42
		Mean	40.81	53.71	58.57	50.38	50.87
2	*Coelachyrum piercei L.*	H1 (Nov '02)	42.67	50.00	64.67	58.33	53.92
		H2 (Feb '03)	41.67	53.33	66.33	54.67	54.00
		H3 (May '03)	41.33	57.00	50.67	44.33	48.33
		H4 (Aug'03)	40.33	55.67	49.00	42.33	46.83
		H5 (Nov '03)	37.33	45.33	60.33	54.67	49.42
		H6 (Feb '04)	38.00	50.33	61.00	50.67	50.00
		H7 (May '04)	42.67	55.67	48.33	43.67	47.59
		Mean	40.57	52.48	57.19	49.81	50.01
3	*Chloris gayana L.*	H1 (Nov '02)	42.67	46.33	65.33	53.33	51.92
		H2 (Feb '03)	42.67	51.67	66.67	52.00	53.25
		H3 (May '03)	43.33	54.67	50.67	42.00	47.67
		H4 (Aug'03)	41.67	52.00	49.00	40.33	45.75
		H5 (Nov '03)	42.00	48.00	62.00	53.67	51.42
		H6 (Feb '04)	40.33	47.00	59.33	48.00	48.67
		H7 (May '04)	45.33	53.67	50.67	42.67	48.09
		Mean	42.57	50.48	57.67	47.43	49.54

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	1.70
Grass species	NS	-
Harvests x Grass species	NS	-
Harvesting time	**	1.28
Harvests x Harvesting time	**	3.39
Grass species x Harvesting time	*	2.22
Harvests x Harvesting time x Grass species	NS	-
CV (%)	7.33	

Table 6 (b). Means of germination of two indigenous rangeland forage grass species and rhodes grass in four harvesting times and seven harvests at JRS, Jimah

Sl. No.	Grass Species	Harvests	Germination %				
			At PM	1WAPM	2WAPM	3WAPM	Mean
1	*Cenchrus ciliaris L*	H1 (Nov '02)	40.00	46.67	61.67	54.33	50.67
		H2 (Feb '03)	41.33	46.00	51.67	36.67	43.92
		H3 (May '03)	45.67	57.67	45.67	37.67	46.67
		H4 (Aug'03)	44.33	59.67	48.00	39.67	47.92
		H5 (Nov '03)	37.33	42.00	55.33	50.33	46.25
		H6 (Feb '04)	39.67	44.67	49.33	37.67	42.84
		H7 (May '04)	46.00	60.33	47.00	39.00	48.08
		Mean	42.05	51.00	51.24	42.19	46.62
2	*Coelachyrum piercei L.*	H1 (Nov '02)	42.33	46.67	58.33	54.33	50.42
		H2 (Feb '03)	43.33	47.00	60.67	41.00	48.00
		H3 (May '03)	46.00	54.00	42.67	35.00	44.42
		H4 (Aug'03)	39.67	60.00	50.00	41.33	47.75
		H5 (Nov '03)	39.00	43.67	52.33	46.33	45.33
		H6 (Feb '04)	38.00	43.33	53.33	39.33	43.50
		H7 (May '04)	48.00	56.00	44.00	36.00	46.00
		Mean	42.33	50.10	51.62	41.90	46.49
3	*Chloris gayana L.*	H1 (Nov '02)	41.67	47.67	59.67	56.33	51.34
		H2 (Feb '03)	39.00	49.33	60.00	41.67	47.50
		H3 (May '03)	47.67	52.33	45.00	37.67	45.67
		H4 (Aug'03)	32.33	54.67	52.67	40.67	45.09
		H5 (Nov '03)	40.33	47.00	55.00	49.00	47.83
		H6 (Feb '04)	36.33	45.67	57.33	38.67	44.50
		H7 (May '04)	49.67	53.67	46.67	39.00	47.25
		Mean	41.00	50.05	53.76	43.29	47.02

Statistical Parameters:	F-Test	LSD (5%)
Harvests	**	1.63
Grass species	NS	-
Harvests x Grass species	*	2.82
Harvesting time	**	1.23
Harvests x Harvesting time	**	3.25
Grass species x Harvesting time	NS	-
Harvests x Harvesting time x Grass species	NS	-
CV (%)	7.54	-

harvest, indicating that hard stage was the best time of harvest. Hard stage can be comparable to either 1WAPM or 2WAPM in our studies at which sufficient moisture in the seed could be lost to become hard, due to high wind blows and hot air temperature of Oman. Chadhokar and Humphreys (1973) had recommended in their studies in Paspalum plicatum cv Rodds Bay that seed could be harvested when 5 % of the seed on the particular inflorescence is abscised. This is just similar to 1WAPM or 2WAPM (see Plates 1-3). Thus the present results have clearly shown that seed in the grass species studied, could be harvested just within couple of weeks after the crop attains physiological maturity to obtain optimum high quality seed yield under climatic conditions of Oman.

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