Germplasm Collection of Rangeland Forage and Medicinal Plant Species in North Oman

Saleem K Nadaf, Safaa M. Al-Farsi and Saleh A. Al-Hinai
Ministry of Agriculture & Fisheries
Oman

Abstract

The collection missions for rangeland germplasm concerning forage and medicinal plant species were organized in North Oman during months of March and April in 2002 and 2003. The representative sites of seven regions of Oman viz. Muscat, North Batinah, South Batinah, Interior, Dhahira, Sharqiya and Musandam were visited for collection mission. The herbaria samples of as many as 60 taxa, consisting 16 forage grass species, 11 forage herb (forb) species, 25 forage shrub species and 8 forage tree species were taken at all sites. The samples of 31 seed accessions of as many as 23 taxa, consisting 16 of forage grass species, 2 of forage herb (forb) species, 10 of forage shrub species and 3 of forage tree species were collected in most sites. Besides, herbaria samples of 31 plant taxa of medicinal importance have been collected of which 10 taxa had seed samples. The Herbaria have been kept preserved in the cupboard and samples of seed accessions have been preserved under cold storage (Deep Freezers) at Seed and Plant Genetic Resources Lab. A database has been collected for passport data in all sites, which will be used for Herbaria samples. The collection missions for rangeland germplasm concerning forage and medicinal plant species were organized in North Oman during months of March and April in 2002 and 2003. A similar mission was supported by ICARDA-APRP in 1998 for the North Oman in which as many as 68 seed accessions of 28 taxa were collected. In the present collection missions, the representative sites of seven regions of Oman viz. Muscat, North Batinah, South Batinah, Interior, Dhahira, Sharqiya and Musandam were visited. The germplasm materials collected are evaluated within the collaborative program between the Sultanate and ICARDA-APRP, for their forage value and water use efficiency, with the objective of replacing the 'water-hungry' exotic forages in Oman. The mission was guided by the list of target species prepared based on our interviews with herders, farmers rearing livestock and the others knowing indigenous medicine. The herbaria samples of as many as 60 taxa, consisting 16 forage grass species (Table 1), 11 forage herb (forb) species (Table 2), 25 forage shrub species (Table 3) and 8 forage tree species (Table 4) were taken at all sites. The samples of 31 seed accessions of as many as 23 taxa, consisting 16 of forage grass species (Table 5), 2 of forage herb (forb) species (Table 6), 10 of forage shrub species (Table 7) and 3 of forage tree species (Table 8) were collected in most sites. Besides, herbaria samples of 31 plant taxa of medicinal importance have been collected (Table 9) of which 10 taxa had seed samples. The Herbaria have been kept preserved in the cupboard and samples of seed accessions have been preserved under cold storage (Deep Freezers) at Seed and Plant Genetic Resources Lab. A database has been collected for passport data in all sites.

Table 1. List of Herbaria of forage-grass species

1. *Aeluropus lagopoides* (L.) Trin. ex Thwaites Family *Poaceae (Gramineae)*
2. *Aristida mutabilis* Trin. & Rupr.Family *Poaceae(Graminae)*
3. Aristida protensa Family *Poaceae (Gramineae)*
4. *Avena barbata* Pott. Cx Lint.Family *Poaceae (Gramineae)*
5. *Cenchrus ciliaris* L. Family *Poaceae(Graminae)*
6. *Cenchrus pennisetiformis* Steud.Family *Poaceae (Gramineae)*
7. *Cymbopogon schoenanthus* (L.) Spreng.Family *Poaceae (Gramineae)*
8. Cyperus aucheri Family *Poaceae (Gramineae)*
9. *Cyperus conglomerates* Rotts.Family *Cyperaceae*
10. Eragrostis caespitosa Family *Poaceae (Gramineae)*
11. *Lasiurus hirsutus* Henrard Family *Poaceae(Gramineae)*
12. Panicum coloratum Family *Poaceae (Gramineae)*
13. *Panicum turgidum* Forsskal Family *Poaceae (Gramineae)*
14. *Pennisetum setaceum* (Forsskal) Chiov. Family *Poaceae (Gramineae)*
15. Pennisetum species Family *Poaceae (Gramineae)*
16. Setaria verticillata Family *Poaceae (Gramineae)*

Table 2. List of Herbaria of forage herb (forb) species

1. Alhagi greacoreum Family *Fabaceae*
2. *Asphodelus fistulosus* L. Family *Liliaceae*
3. *Blepharis ciliaris* (L.), B.L. Burtt. Family *Acanthaceae*
4. *Cleome glaucescents* DC. Family *Capparaceae*
5. *Convolvulus arvensis* L. Family *Convolvulaceae*
6. *Convolvulus* cf. *pilosellifolius* Desr.Family *Convolvulaceae*
7. *Diplotaxis harra* (Forsskal) Boiss. Family *Crucifexae*
8. *Helianthemum lippii* (L.) Dum-Cours. Family *Cistaceae*
9. *Heliotropium calcareum* Stocks Family *Boroginaceae*
10. *Reichardia tingitana* (L.) Roth. Family *Compositae*
11. *Zygophyllum simplex* L Family *Zygophyllacene*

Table 6. List of seed accessions of forage herb (Forb) species

1. *Cleome glaucescents* DC.	-	1
2. *Diplotaxis harra* (Forsskal) Boiss.	-	1
Total	-	**2**

Family *Moraceae*
4. *Ficus palmata* Forsskal. Family *Moraceae*
5. *Maerua crassifolia* Forsskal. Family *Capparaceae*
6. *Prosopis cineraria* (L.) Drule. Family *Mimosaceae*
7. *Tamarix aphylla* (L.) Karst. Family *Tamaricaceae*
8. Ziziphus spina-christi (L.) Desf. Family Rhamnaceae

Table 5. List of seed accessions forage-grass species

1.	*Aeluropus lagopoides* (L.) Trin. ex Thwaites	-	1
2.	*Aristida mutabilis* Trin. & Rupr.	-	1
3.	*Avena barbata* Pott. Cx Lint.	-	1
4.	*Cenchrus ciliaris* L.	-	6
5.	*Cyperus conglomerates* Rotts.	-	1
6.	Eragrostis caespitosa	-	1
7.	*Lasiurus hirsutus* Henrard	-	2
8.	Panicum coloratum	-	1
9.	Panicum turgidum	-	2
	Total	**-**	**16**

Table 7. List of seed accessions of forage shrub species

1.	*Acacia oerfota* (Forsskal) Schweinf.	-	1
2.	*Aerva javanica (Burm.f.)* Juss. ex J.A. Schultes	-	1
3.	Calligonum comosum L Herit.	-	2
4.	Euphorbia riebekii	-	1
5.	*Grewia erythraea* Schweinf.	-	1
6.	*Leptadenia pyrotechnica* (Forsskal) Decne	-	1
7.	*Lycium shawii* Roem & Schult.	-	1
8.	*Rhus aucheri* Boiss.	-	1
9.	*Suaeda vermilulata* Forsskal ex J.F. Gmel	-	1
	Total		**10**

Table 8. List of seed accessions of forage-tree species

1.	*Acacia tortilis* (Forsskal) Hayne.	-	1
2.	*Prosopis cineraria* (L.) Drule.	-	1
3.	Ziziphus spina-christi (L.) Desf.	-	1
	Total		**13**

Table 3. List of Herbaria of forage shrub species

1. *Acacia oerfota* (Forsskal) Schweinf. Family *Mimosaceae*
2. *Aerva javanica (Burm.f.)* Juss. ex J.A. Schultes Family *Amaranthaceae*
3. Calligonum comosum L Herit. Family *Polygonaceae*
4. *Calligunum crinitum* Boiss subsp. *arabicum* (Sosk.) Sosk.Family P*olygonaceae*
5. *Capparis spinosa* L. Family *Capparaceae*
6. *Dyerophytum indicum* (Gibs. Ex Wight) Kuntze. Family *Plumbaginaceae*
7. *Ebenus stellata* Boiss.Family *Fabaceae*
8. *Euphorbia larica* BoissFamily *Euphorbiaceae*
9. Euphorbia riebekii Family *Euphorbiaceae*
10. *Fagonia indica* Burm. F. Family *Zygophyllaceae*
11. *Grewia erythraea* Schweinf. Family *Tiliaceae*
12. *Haloxylon salicornicum* (Moq.) Bunge ex Boiss. Family *Chenopodiaceae*
13. *Heliotropium kotschyi* (Ledeb.) Guerke. Family *Boraginalene*
14. *Jaubertia aucheri* Guill Family *Rubiaceae*
15. *Leptadenia pyrotechnica* (Forsskal) Decne Family *Asclepiadaceae*
16. *Lycium shawii* Roem & Schult. Family *Solanceae*
17. *Monotheca buxifolia* (Falc.) A.DC. Family *Sapotaceae*
18. *Periploca aphylla Decne*. Family *Asclepiadaceae*
19. *Pteropyrum scoparium* Janb. & Spach Family *Polygonaceae*
20. *Rhus aucheri* Boiss. Family *Anacardiaceae*
21. *Sagetaria spiciflora* (A. Rich.) Hutch. & Druce Family *Rhamnaceae*
22. *Salsola rubescens* Franch Family *Chenopodiaceae*
23. *Suaeda vermilulata* Forsskal ex J.F. Gmel Family *Chenopudiaceae*
24. *Taverniera glabra* Boiss Family *Fabaceae*
25. *Zygophyllum qatarense* Hadidi Family *Zygophyllaceae*

Table 4. List of Herbaria of forage-tree species

1. *Acacia ehrenbergiana* Hayne. Family *Mimosaceae*
2. *Acacia tortilis* (Forsskal) Hayne. Family *Mimosaceae*
3. *Ficus cordata* Thumb sub sp. *salicifolia* (Vahl) C.C. Berg

Table 9. List of plant taxa of medicinal importance

	Scientific Name	Local name	Herbarium	Seed
1.	*Acridocarpus orientalis*	*Qaphas*	*Yes*	*No*
2.	*Aerva javanica*	*Ra'*	*Yes*	*Yes*
3.	*Alhagi graecorum*	*Arnep*	*Yes*	*No*
4.	*Aloe vera*	*Muql, Siql*	*Yes*	*No*
5.	*Asphodelus fistulosus*	*Mubsaila*	*Yes*	*Yes*
6.	*Capparis spinosa*	*Lisaf*	*Yes*	*No*
7.	*Caralluma aucheriana*	*Dhiz*	*Yes*	*No*
8.	*Caralluma quadrangula*	*Sereyon*	*Yes*	*No*
9.	*Cassia italica*	*Ashriq*	*Yes*	*No*
10.	*Citrulus colocynthis*	*Handal*	*Yes*	*Yes*
11.	*Cleome glaucescense*	*Mukhaiblutil-sham*	*Yes*	*Yes*
12.	*Convolvulus cf pilosetiformis*	*Nijja*	*Yes*	*No*
13.	*Crucianella membraneaea*	*Muhtadi*	*Yes*	*No*
14.	*Cymbopogon schoenanthus*	*Sakhbar*	*Yes*	*No*
15.	*Dodonaea viscosa*	*Shahs*	*Yes*	*No*
16.	*Fagonia indica*	*Shikya*	*Yes*	*No*
17.	*Indigofera intricata*	*Uzlim*	*Yes*	*No*
18.	*Lavendula subnuda*	*Haraaq, Sawmar*	*Yes*	*No*
19.	*Lycium shawii*	*Qasad*	*Yes*	*Yes*
20.	*Maerua crassifolia*	*Sarh*	*Yes*	*No*
21.	*Moringa perigrina*	*Shuh*	*Yes*	*No*
22.	*Pennisetum setaceum*	*Halfa*	*Yes*	*No*
23.	*Pteropyrum scoparium*	*Sidaf*	*Yes*	*No*
24.	*Rhazya stricta*	*Harmal*	*Yes*	*Yes*
25.	*Rhus aucheri*	*Qataf*	*Yes*	*Yes*
26.	*Salvadora persica*	*Raq*	*Yes*	*Yes*
27.	*Tamarix aphylla*	*Athal*	*Yes*	*No*
28.	*Taverniera glabra*	*Asmat*	*Yes*	*No*
29.	*Tephrisia purpurea*	*Dhafra*	*Yes*	*Yes*
30.	*Teucrium stocksianum*	*Jyaad*	*Yes*	*No*
31.	*Zizipus spina-christi*	*Sidr*	*Yes*	*Yes*

Differential Response of Indigenous Rangeland Forage Species to Salinity Imposed From Germination Stage

Saleem K Nadaf, Safaa M. Al-Farsi and Saleh A. Al-Hinai
Ministry of Agriculture & Fisheries,
Oman

Abstract

Two indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE) and Coelachyrum piercii L.(UAE) collected under ICARDA- APRP Phase- I were investigated under ICARDA- APRP Phase-II for their response to seven levels of irrigation water salinity imposed right from stage of germination viz. Control (1 dS m-1), 3, 6, 9, 12, 15 and 18 dS m-1 along with other perennial fodder grasses viz. Rhodes grass (Chloris gayana L.cvs. Katambora and Callide) and Buffel grass (Cenchrus ciliaris L cv. of Australia) from October 2001.The results of the study spanning 10 cuts indicated that effects of salinity, species, cuts and their interactions were highly significant ($P < 0.01$) with respect to all the characters studied. Adverse effect of salinity was evident in each species for the agronomic traits studied. Indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE), Coelachyrum piercii L. (UAE) and Australian Cenchrus were severely affected by salinity with respect to plant height, green and dry matter weights in subsequent cuts at low salinity levels beyond 6 dS m-1. Both Cenchrus species and Coelachyrum piercii L. (UAE) did not germinate in the salinity levels beyond 9 and 6 dS m-1, respectively. Cenchrus ciliaris L. (UAE) germinated at 12 dS m-1, collapsed after first cut. Rhodes grass cultivars showed less adverse effect even in progressive cuts particularly in the salinity levels lesser than 9 dS m-1 for all agronomic traits indicating their distinctive superiority over other two grass species. Salinity tolerance of genotypes was assessed using the concepts of both stress susceptibility index at each higher salinity level in relation to control (lowest salinity level) and mean value over the salinity treatments with respect to each agronomic character. It was found that Rhodes grass cultivars are more tolerant to salinity especially at and below 6 dS m-1 in their progressive life span through cuts.

Introduction

Salinity occurs worldwide and is found in all the continents except Antarctica (Szabolcs, 1985). More than half the world's ground water supplies are already saline, and the proportion is increasing as demand for water outstrips supply (Biosaline Agriculture Center, 2000). The crop productivity in arid and semiarid agricultural areas is severely limited by salinity in combination with drought and heat. In the rangelands like Dhofar Jabal area in the Sultanate of Oman, a gradual loss of palatable species has been noticed to the level of near extinction to extinction thus affecting the originally rich plant diversity (Ghazanfar et al., 1995). Such degradation of rangelands has been primarily attributed to overgrazing by the increasing number of animals. Here also, increased seawater intrusion has been noticed due to over-pumping turning gradually ground water resources saline. Several aquifers have reached negative water balance between supplies and demands causing heavy impact on the water quality (FAO, 1991; Koll and Ghawas, 2000). Under such conditions, saline tolerant indigenous rangeland grass species would be valuable either for reseeding in the degraded rangelands at corresponding salinity sites or testing/ breeding for their suitability under existing forage production system in the areas affected by salinity (Peacock et al., 2000). Plant breeders along with physiologists are now modifying plants to suit adverse saline soil or irrigation water conditions while maintaining reasonable and reliable yields (Shannon,1985; Wyn Jones and Gorham, 1986; Gorham, 1991; Qualset and Corke, 1991).

It seems that a very few scientists have attempted to investigate on salinity in forage species. Hughes et al. (1975) studied forage yields of five grass species in soil under greenhouse conditions with NaCl additions of 0, 5 000, 10 000, 20 000 ppm. Only Puccinellia. Distans L. showed the least reduction of 23% in 20 000 PPM as compared to other grass species. Guggenheim and Waisel (1977) investigated the effects of irrigation water salinity, temperature and nitrogen fertilization on growth and composition of Rhodes grass. Maas (1985) presented yield reductions caused by soil salinity for 71 agricultural crops that included grasses and forage crops. Pasternak et al. (1993) found the salinity tolerance of six forage species studied under 1.2 to 9.5 dS m-1 of irrigation water as Salt (spike) grass (Distichlis spikata L.) > Bermuda grass (Cynodon dactylon L. Pers.) > Seashore paspalum (Paspalim vaginatum Swartz.) > Rhodes grass (Chloris gayana Kunth cv. Common) > Kallar grass (Leptochloa

Effect of Salinity on Growth

Indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE) and Coelachyrum piercei L. (UAE) were severely affected by salinity as evidenced by their survival up to tenth cut at only control and 3 dS m-1. They were affected with respect to plant height, green and dry matter weights progressively after each cut in high salinity levels. Coelachyrum piercei collapsed totally after seventh cut at 9 dS m-1. Cenchrus ciliaris L. (UAE) collapsed after first cut in 12 dS m-1 and after third cut at salinity levels of 9 and 6 dS m-1. Australian Buffel was moderately affected by salinity with its collapse after third cut at 9 dS m-1 while it survived even at 6 dS m-1 at tenth cut. Rhodes grass cultivars showed less adverse effect even in progressive cuts at 3 and 6 dS m-1 up to tenth cut for all agronomic traits indicating their distinctive superiority over other two grass species. They, however, started collapsing after third cut at 18 dS m-1, after fourth cut at 15 dS m-1 , after fifth cut at both 12 and 9 dS m-1 (Tables 3-6).

Plant Height

There was significant reduction ($P<0.05$) in mean plant height with increase in the level of salinity in all the cuts in all the grass species (Table 3). Indigenous cultivars of grass species viz. Coelachyrum piercei L. and Cenchrus ciliaris L were very much affected as compared to other grass species. Coelachyrum piercei had mean height of 64.60 cm at control as compared to 33.40 cm at 6 dS m-1 while indigenous Cenchrus ciliaris had a low plant height of 0.70 cm at 12 dS m-1 as against 69.03 cm at control. Australian Buffel had a moderate effect of salinity in respect of plant height (69.87 cm at control vs 14.27 cm at 9 dS m-1). Rhodes grass cultivars had been comparatively less affected by salinity as they had higher mean values in all the levels. Among the cultivars of Rhodes grass, Katambora appeared to perform better at 3 dS m-1 in respect of plant height (90.70 cm) as against 97.77 cm at control.

There was significant ($p<0.05$) reduction in plant height from first to last cut in both Cenchrus and Coelachyrum species not only in control but also in all salinity levels. In case of Rhodes grass, it was evident only in the salinity levels above 9 dS m-1.

Number of Tillers/ Plant

Tillers were significantly reduced ($P<0.05$) gradually with increase in the level of salinity, in general, in all the cuts in all the grass species (Table 4). Indigenous cultivars of grass species viz. Coelachyrum piercei L. and Cenchrus ciliaris L were much adversely affected as compared to other grass species. Mean number of tillers was greatly reduced from 21.93 at control to 9.40 at 9 dS m-1 in Coelachyrum piercei while it was reduced from 46.93 at control to 0.2 at 12 dS m-1 in indigenous Cenchrus ciliaris. The effect of salinity on Australian Buffel was, however, moderate in respect of number of tillers (39.90 at control vs 16.97 at 9 dS m-1). Rhodes grass cultivars had comparatively less effect of salinity as they had higher mean values in all the levels where they survived. Among the cultivars of Rhodes grass, Callide had 12.43 tillers per plant at 6 dS m-1 as against 20.33 cm at control. Cenchrus species in general produced numerous tillers under salinity conditions (Table 4) as compared to other grass species indicating its mechanism for survival under stress.

Green and Dry Matter Weights

There was gradual and significant reduction ($P<0.05$) in both green and dry matter weights with increase in the level of salinity in all the cuts in all the grass species (Tables 5 and 6). Indigenous cultivars of grass species viz. Coelachyrum piercei L. and Cenchrus ciliaris L were severely affected by salinity as compared to other grass species. Coelachyrum piercei had mean green and dry matter weights of 51.44 and 14.26 g at control as compared to 13.62 and 3.34 g at 6 dS m-1. Indigenous Cenchrus ciliaris had low green and dry matter weights of 3.26 and 1.222 g at 9 dS m-1 as against 114.06 and 39.04 g at control. However, Australian Buffel had a moderate effect of salinity in respect of both green and dry matter weights as it had mean green and dry matter weights of 116.87 and 36.45 g at control as compared to 49.57 and 11.44 g at 6 dS m-1. The effect of salinity on Rhodes grass cultivars was observed to be of lower magnitude as they had higher mean values in all the levels than other grass species (Table 5). Among the cultivars of Rhodes grass, Katambora consistently performed better than callide not only in control but also in all the salinity levels wherever it survived in respect of both green and dry matter weights. Katambora had mean green and dry matter weights of 194.80 and 60.22 g at control as compared to 87.59 and 22.53 g at 6 dS m-1 while Katambora had low green and dry matter weights of 79.57 and 20.17 g at 6 dS m-1 as against 161.70 and 47.71 g at control. In general, Rhodes grass cultivars gave higher green matter weights through cuts not only in control but also in all the salinity levels indicating their superiority in performance under salinity as compared to other grass species.

Mean Values and Stress Susceptibility Indexes

Table 7 provides the mean values over cuts of four characters of different grass species in control and different salinity levels along with stress susceptibility indexes. Among the grass species studied, Rhodes grass cultivars had higher mean values in all the salinity levels than the other grass species in respect of plant height, green and dry matter weights indicating their relative tolerance to salinity. Cenchrus species were showed more superiority as compared to Rhodes grass cultivars with respect to number of tillers only at control and 3 dS m-1 but also at high salinity levels tillers were significantly reduced in these species as compared to that in Rhodes grass cultivars. Coelachyrum piercei had lowest mean values for all the characters in all the salinity levels.In respect of S (Stress susceptibility index) values, Rhodes grass cultivars had the lowest S values for all the characters in all the salinity levels as compared to the other grass species indicating their consistency and relative tolerance to salinity (Table 7). S values of the grass species for each character with respect to each cut (Tables 3 to 5) in general indicated similar nature of tolerance of grass species to salinity as observed based on mean values over cuts (Table 7). In general, S values in progressive cuts were of higher order in all the grass species under higher salinity levels indicating that perennial grass species had gradual loss of ability in tolerance as the cuts progressed. This was attributed to gradual deterioration of characters in progressive cuts under higher salinity levels, which would in turn affect stand persistency and longevity of the grass species. This phenomenon was quite apparent in Coelachyrum piercei and Cenchrus species as compared to Rhodes grass cultivars. The indigenous species viz. Cenchrus ciliaris (UAE) and Coelachyrum piercei (UAE) used in the present study were from the germplasm collections in the UAE from the range land site having 1 dS m-1 (Peacock, J.–Personal Communication). Hence, they appear to lack, as observed in the present study, the productive potentialities particularly under saline conditions, similar to those of cultivated irrigated forages like Rhodes grass.

Acknowledgements

We are grateful to the Director General of Agriculture, Assistant DG of Agriculture Research & Extension and Director of Agriculture Production Research Center, for their assistance and encouragement in conducting experiments. Thanks are also to Mrs. Majda S.S. Al-Zadjali and Mr. Muneer S.S. Al-Yahyai for plant, soil and water analyses.

References

AOAC. 1984. Official methods of analysis. 14th ed. Association of Official Analytical Chemists, Washington, D.C. USA

Ashraf, M. and Oleary, J.W. 1996. Responses of some newly developed salt-tolerant genotypes of spring wheat to salt stress. 1. yield components and ion distribution. J. Agron.& Crop Sci.- Zeitschrift fur Acker and Pflanzenbau. 176 91-101.

Biosaline Agriculture Center. 2000. Web Site of Biosaline Agriculture Center, Islamic Development Bank, 2000.

Chapman, H.D. and Pratt, P.F. 1961. Methods of analysis for soils, plants and waters. Univ. of California. USA.

Chhipa, B.R. and Lal, P. 1995. Na/K ratios as the basis of salt tolerance in wheat. Aust. J.Agric.Res. (Australia). 46 533-539.

Devine, T.E. 1982. Genetic fitting of crops to problem soils. In Breeding plants for less favorable environments. Eds. M.N Christiansen and C.F. Lewig. John Wiley, New York. pp. 143-173.

Dvorak, J. and Ross, K. 1986. Expression of tolerance of Na+, K+, Mg2+, Cl-, and SO42- ions and sea water in the amphiploid of Triticum aestivum x Elytrigia elongata. Crop Sci. 26 658-660.

El-Agrodi, M.W.M., El-Banna, Y., El-Shirafy, Z.M. and Taha, A.A. 1988 b. Effect of different EC values of nutrient solution on wheat and barley plants; using a nutrient film technique. J. Agric. Sci., Mansoura Univ. (Egypt). 13(2) 987-994.

FAO. 1991. Report of FAO programming / project identification mission to the Sultanate of Oman. Food Agriculture Organization, Italy, Rome.

Fischer, R.A. and Maurer, R.. 1978. Drought resistance in spring wheat cultivars I. Grain yield responses. Australian J. Agric. Res. 29 897-912.

Ghazanfar, S.A., Miller, A.G., Mc Leish, I., Cope, T.A., Cribb, P. and Al-Rawahi, S.H. 1995. Plant Conservation in Oman. Part-I. A study of the endemic, regionally endemic and threatened plants of the Sultanate of Oman. April 1995. 15 p. Sultan Qaboos University , Oman.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. Second Ed. The International Rice Research Institute, Philippines.

Gorham, J. 1991. Role of the physiologist in breeding for salt tolerance. Plant salinity research, New challenges. Proceedings of the International Conference on Agriculture Management of Salt-affected area in Agadir Morocco. Ed. R. Choukar-alla, Publ.I.A.V. Hassan, Morocco.

Grieve, C.M., S.M. Lesch., L.E. Francois and E.V. Maas. 1992. Analysis of main-spike yield components in salt-stressed wheat. Crop Sci. 32 697-703.

Guggenheim, J. and Waisel, Y. 1977. Effects of salinity, temperature and nitrogen fertilization on growth and composition of Rhodes grass (Chloris gayana Kunth). Plant and Soil. 47 431-440.

Hughes, T.D., Butler, J.D. and Sanks, G.D. 1975. Salt tolerance and suitability of various grasses for saline roadsides. J. Environ. Quality. 4 65-68.

Kelmen, W.M. and Qualset, C.O. 1991. Breeding for salinity stressed environments Recombinant inbred wheat lines under saline irrigation. Crop Sci. 31 1436-1442.

Kingsbury, R.W. and Epstein, E. 1984. Selection for salt resistant spring wheat. Crop Sci. 24 310-315.

Koll, E.B.A. and Ghawas, A.M.S. 2000. Effect of Fog-water capture, reseeding, contour furrowing and fertilization on botanical composition and productivity of mountainous natural grazing- lands of Dhofar. Paper presented in the First Oman-Japan Joint Symposium on water resources and greening in desert. Feb. 14-16 2000. Sultanate of Oman.

Maas, E.V. 1985. Crop tolerance to saline sprinkler water. Plant and Soil. 89. 273-284.

Maas, E.V. and Hoffman, G.J. 1977. Crop salt tolerance- Current assessment. J. Irrig. And Drainage Div., ASCE 103(IR2) 115-134.

Nadaf, S.K., Al-Khamisi, S.A., Al-Lawati, A.H. and Sidahmed, O.A. 2000 a. Differential response of wheat (Triticum aestivum L.) to salinity.I. Agronomic and yield attributes. Agricultural Sci. Sultan Quaboos Univ., Oman .

Nadaf, S.K., Al-Khamisi, S.A., Al-Lawati, A.H. and Sidahmed, O.A. 2000 b. Differential response of wheat (Triticum aestivum L.) to salinity.II. Ion Concentrations and Protein. Agricultural Sci. Sultan Quaboos Univ., Oman.

Nadaf, S.K., Al-Farsi, S. M., Al-Hinai, S.A., Al-Khamisi, S.A., Al-Bakri, A.N and Al-Lawati, A.H. 2002. Response of indigenous rangeland and cultivated forage species to salinity. Paper presented at Regional Technical Coordination Meeting (RTCM) held at Sana'a, Yemen from 28 Sep to 2 Oct 2002. Annual Report of APRP 2001-2002. pp 80-95.

Pasternak, D., Nerd, R.A. and De-Malach, Y. 1993. Irrigation with brackish water under desert conditions. IX. The salt tolerance of six forage crops. Agri. Water Manage. 24 321-334.

Peacock, J.M., Ferguson, M.E., Alhadrami, G.A., McCann, I.R., Al Hajoj, A., Saleh, A. and Karnik, R. 2000. Conservation through utilization-a case study of the indigenous forage grasses of the Arabian Peninsula. Paper presented at the International Conference on the Conservation of Biodiversity in the Arid Regions. Kuwait. March 27-29, 2000.

Qualset, C.O. and Corke, H. 1991. Plant breeding to develop varieties for crop production with alternating saline and non saline irrigation A case study of wheat in California. Plant salinity research, New challenges. Proceedings of the International Conference on Agriculture Management of Salt-affected areas held in Agadir Morocco. Ed. R. Choukar-alla, Publ.I.A.V. Hassan, Morocco.

Rawson, H.M., Richards, R.A. and Munns, R. 1988. An examination of selection criteria for salt tolerance in wheat, barley and tritical genotypes. Australian J. Agric. Res. 39 (5) 759-772.

Richards, R.A., Dennet, C.W., Quaslet, C.O., Epstein, E., Norlyn, J.D. and Winslow, M.D. 1987. Variation in yield of grain and biomass in wheat, barley and triticale in salt affected field. Field Crops Res. 15 277-287.

Szabocs, I. 1985. Salt-affected soils- a world problem. International Symposium on Reclamation of Salt-Affected soils. China. pp.30-47.

Wyn Jones, R.G. and Gorham, J. 1986. The potential for enhancing the salttolerance of wheat and other important crop plants. Outlook on Agric. 15 33-39.

Table 1. Values of some physical and chemical characteristics of the experimental soil

Characteristics	experimental soil
PHYSICAL	
Coarse sand (%)	21.70
Fine sand (%)	63.00
Silt (%)	3.90
Clay (%)	11.40
Texture	Sand
CHEMICAL	
EC_e (dS m^{-1})	5.70
pH	7.80
Soluble Cations (meq./100 g)	
Na	65.90
K	0.77
Soluble Anions (meq./ 100 g)	
Cl	59.50
N (%)	0.04
Av. P (meq./100 g)	15.76

Table 2. Values of some chemical characteristics of irrigation water treatments

Ionic contents	1 dS m^{-1}	3 dS m^{-1}	6 dS m^{-1}	9 dS m^{-1}	12 dS m^{-1}	15 dS m^{-1}	18 dS m^{-1}
Cations ($mmol_c$/l)							
Ca	3.80	4.50	5.40	6.20	7.00	7.80	8.70
Mg	9.20	12.20	18.50	28.40	38.80	49.90	60.10
Na	5.30	26.70	43.40	56.10	66.80	77.10	88.20
K	0.30	0.70	1.30	1.70	2.10	2.50	2.90
Anions ($mmol_c$/l)							
HCO_3	2.50	2.40	2.50	2.40	2.30	2.50	2.80
CO_3	0.60	1.20	0.80	1.20	1.00	1.20	1.40
Cl	7.50	23.00	50.50	77.00	105.00	130.00	160.00
SO_4	8.00	18.20	14.80	11.80	6.40	9.40	12.20

Table 3. Mean plant height (cm) of grass species and their stress susceptibility indexes (Sc.j) based on plant height per se

Grass Species +	No. of Cut	Control	3 dS m^{-1}	6 dS m^{-1}	9 dS m^{-1}	12 dS m^{-1}	15 dS m^{-1}	18 dS m^{-1}	Mean	Sc.3 †	Sc.6	Sc.9	Sc.12	Sc.15	Sc.18
1	1	73.00	63.00	58.33	49.33	0.00	0.00	0.00	34.81	1.83	1.07	0.41	1.00	1.00	1.00
	2	75.67	62.67	68.00	48.33	0.00	0.00	0.00	36.38	2.29	0.54	0.45	1.00	1.00	1.00
	3	66.67	67.67	58.67	45.00	0.00	0.00	0.00	34.00	-0.20	0.64	0.41	1.00	1.00	1.00
	4	46.00	44.67	38.33	0.00	0.00	0.00	0.00	18.43	0.39	0.89	1.26	1.00	1.00	1.00
	5	68.33	60.67	55.33	0.00	0.00	0.00	0.00	26.33	1.50	1.02	1.26	1.00	1.00	1.00
	6	68.67	69.00	52.67	0.00	0.00	0.00	0.00	27.19	-0.06	1.25	1.26	1.00	1.00	1.00
	7	87.67	84.67	77.33	0.00	0.00	0.00	0.00	35.67	0.46	0.63	1.26	1.00	1.00	1.00
	8	88.33	81.33	71.00	0.00	0.00	0.00	0.00	34.38	1.06	1.05	1.26	1.00	1.00	1.00
	9	57.33	48.67	46.67	0.00	0.00	0.00	0.00	21.81	2.02	0.99	1.26	1.00	1.00	1.00
	10	67.00	64.00	41.67	0.00	0.00	0.00	0.00	24.67	0.60	2.02	1.26	1.00	1.00	1.00
Mean		69.87	64.63	56.80	14.27	0.00	0.00	0.00							
2	1	47.33	47.00	45.33	0.00	0.00	0.00	0.00	19.95	0.08	0.09	1.00	1.00	1.00	1.00
	2	82.33	80.67	45.00	0.00	0.00	0.00	0.00	29.71	0.22	0.94	1.00	1.00	1.00	1.00
	3	53.33	50.33	50.67	0.00	0.00	0.00	0.00	22.05	0.62	0.10	1.00	1.00	1.00	1.00
	4	64.00	62.00	48.33	0.00	0.00	0.00	0.00	24.90	0.34	0.51	1.00	1.00	1.00	1.00
	5	64.33	67.67	60.00	0.00	0.00	0.00	0.00	27.43	-0.57	0.14	1.00	1.00	1.00	1.00
	6	68.33	59.67	38.00	0.00	0.00	0.00	0.00	23.71	1.39	0.92	1.00	1.00	1.00	1.00
	7	66.00	58.67	46.67	0.00	0.00	0.00	0.00	24.48	1.22	0.61	1.00	1.00	1.00	1.00
	8	74.33	66.00	0.00	0.00	0.00	0.00	0.00	20.05	1.23	2.07	1.00	1.00	1.00	1.00
	9	61.67	50.00	0.00	0.00	0.00	0.00	0.00	15.95	2.07	2.07	1.00	1.00	1.00	1.00
	10	64.33	45.00	0.00	0.00	0.00	0.00	0.00	15.62	3.29	2.07	1.00	1.00	1.00	1.00
Mean		64.60	58.70	33.40	0.00	0.00	0.00	0.00							
3	1	66.67	60.00	35.00	6.33	7.00	0.00	0.00	25.00	0.58	0.53	0.95	0.90	1.00	1.00
	2	65.33	61.00	13.00	8.33	0.00	0.00	0.00	21.10	0.39	0.90	0.92	1.01	1.00	1.00
	3	58.67	58.33	25.00	20.00	0.00	0.00	0.00	23.14	0.03	0.64	0.69	1.01	1.00	1.00
	4	67.00	40.67	0.00	0.00	0.00	0.00	0.00	15.38	2.29	1.12	1.05	1.01	1.00	1.00
	5	79.33	53.00	0.00	0.00	0.00	0.00	0.00	18.90	1.94	1.12	1.05	1.01	1.00	1.00
	6	76.67	53.33	0.00	0.00	0.00	0.00	0.00	18.57	1.78	1.12	1.05	1.01	1.00	1.00
	7	71.67	66.67	0.00	0.00	0.00	0.00	0.00	19.76	0.41	1.12	1.05	1.01	1.00	1.00
	8	81.33	76.67	0.00	0.00	0.00	0.00	0.00	22.57	0.33	1.12	1.05	1.01	1.00	1.00
	9	63.67	54.67	0.00	0.00	0.00	0.00	0.00	16.90	0.82	1.12	1.05	1.01	1.00	1.00
	10	60.00	47.67	0.00	0.00	0.00	0.00	0.00	15.38	1.20	1.12	1.05	1.01	1.00	1.00
Mean		69.03	57.20	7.30	3.47	0.70	0.00	0.00							
4	1	99.67	98.00	87.00	69.00	67.67	29.33	11.33	66.00	0.25	0.74	0.49	0.49	0.90	1.00
	2	95.67	85.00	88.00	81.00	77.67	69.67	42.33	77.05	1.70	0.47	0.24	0.29	0.34	0.63
	3	89.33	88.00	84.33	72.67	71.00	65.67	56.00	75.29	0.23	0.33	0.30	0.31	0.34	0.42
	4	93.33	86.67	67.67	60.00	53.33	41.33	0.00	57.48	1.09	1.61	0.57	0.65	0.71	1.13
	5	106.33	89.67	81.00	78.33	65.66	0.00	0.00	60.14	2.39	1.40	0.42	0.58	1.27	1.13
	6	92.67	89.00	82.67	0.00	0.00	0.00	0.00	37.76	0.60	0.63	1.59	1.53	1.27	1.13
	7	103.00	88.00	75.67	0.00	0.00	0.00	0.00	38.10	2.22	1.55	1.59	1.53	1.27	1.13
	8	103.00	104.00	106.00	0.00	0.00	0.00	0.00	44.71	-0.15	-0.17	1.59	1.53	1.27	1.13
	9	88.33	85.00	52.67	0.00	0.00	0.00	0.00	32.29	0.57	2.37	1.59	1.53	1.27	1.13
	10	99.33	93.67	80.00	0.00	0.00	0.00	0.00	39.00	0.87	1.14	1.59	1.53	1.27	1.13
Mean		97.07	90.70	80.50	36.10	33.53	20.60	10.97							
5	1	89.67	82.00	65.00	67.00	59.33	40.67	6.67	58.62	0.74	1.81	0.43	0.55	0.73	1.04
	2	96.33	81.67	82.67	79.67	74.67	66.67	30.00	73.10	1.31	0.93	0.29	0.36	0.41	0.77
	3	104.33	81.00	82.00	72.33	65.33	68.33	57.67	75.86	1.93	1.41	0.52	0.61	0.46	0.50
	4	87.00	74.33	70.67	63.67	57.33	52.00	0.00	57.86	1.25	1.23	0.45	0.55	0.54	1.12
	5	89.00	61.33	82.00	80.67	83.67	0.00	0.00	56.67	2.68	0.52	0.16	0.10	1.34	1.12
	6	87.33	74.33	79.00	0.00	0.00	0.00	0.00	34.38	1.28	0.63	1.69	1.62	1.34	1.12
	7	90.00	88.67	76.00	0.00	0.00	0.00	0.00	36.38	0.13	1.02	1.69	1.62	1.34	1.12
	8	85.33	81.33	78.00	0.00	0.00	0.00	0.00	34.95	0.40	0.56	1.69	1.62	1.34	1.12
	9	85.00	81.67	65.00	0.00	0.00	0.00	0.00	33.10	0.34	1.54	1.69	1.62	1.34	1.12
	10	76.33	80.67	74.33	0.00	0.00	0.00	0.00	33.05	-0.49	0.17	1.69	1.62	1.34	1.12
Mean		89.03	78.70	75.47	36.33	34.03	22.77	9.43							

\+ 1. *Cenchrus cilaris L* (Australia); 2. *Coelachyrum piercei L*.(Local); 3. *Cenchrus ciliaris L*. (local);
4. *Chloris gayana L*. Katambora; 5. *Chloris gayana L*. Callide

Statistical Parameters

	F-Test	LSD (5%)
Salinity	**	2.15
Grass species	**	1.81
Salinity x Grass species	**	4.80
Cuts	**	2.57
Salinity x Cuts	**	6.79
Grass species x Cuts	**	5.74
Salinity x Grass species x Cuts	**	15.18

**- Significant at 0.01 level of probability

† - Stress susceptibility index of 'j' (dS), high salinity treatment relative to 'c' (0.80 dS), low salinity treatment

Table 4. Mean number of tillers of grass species and their stress susceptibility indexes (Sc.j) based on number of tillers per se

Grass Species +	No. of Cut	Control	3 dS m-1	6 dS m-1	9 dS m-1	12 dS m-1	15 dS m-1	18 dS m-1	Mean	Sc.3 †	Sc.6	Sc.9	Sc.12	Sc.15	Sc.18
1	1	13.67	9.67	7.00	6.00	0.00	0.00	0.00	5.19	0.94	0.85	0.58	1.00	1.00	1.00
	2	13.33	12.33	13.67	4.00	0.00	0.00	0.00	6.19	0.24	-0.04	0.73	1.00	1.00	1.00
	3	21.00	15.67	16.33	4.00	0.00	0.00	0.00	8.14	0.82	0.39	0.84	1.00	1.00	1.00
	4	33.00	29.00	27.67	0.00	0.00	0.00	0.00	12.81	0.39	0.28	1.04	1.00	1.00	1.00
	5	44.00	20.67	19.67	0.00	0.00	0.00	0.00	12.05	1.70	0.96	1.04	1.00	1.00	1.00
	6	45.00	31.00	19.33	0.00	0.00	0.00	0.00	13.62	1.00	0.99	1.04	1.00	1.00	1.00
	7	57.67	41.33	18.00	0.00	0.00	0.00	0.00	16.71	0.91	1.20	1.04	1.00	1.00	1.00
	8	66.33	33.33	19.67	0.00	0.00	0.00	0.00	17.05	1.60	1.22	1.04	1.00	1.00	1.00
	9	48.00	40.33	18.33	0.00	0.00	0.00	0.00	15.24	0.51	1.08	1.04	1.00	1.00	1.00
	10	57.00	41.33	10.00	0.00	0.00	0.00	0.00	15.48	0.88	1.43	1.04	1.00	1.00	1.00
Mean		39.90	27.47	16.97	1.40	0.00	0.00	0.00							
2	1	10.67	9.33	9.00	0.00	0.00	0.00	0.00	4.14	1.47	0.27	1.00	1.00	1.00	1.00
	2	14.67	14.00	11.33	0.00	0.00	0.00	0.00	5.71	0.54	0.40	1.00	1.00	1.00	1.00
	3	12.33	8.00	7.33	0.00	0.00	0.00	0.00	3.95	4.14	0.71	1.00	1.00	1.00	1.00
	4	21.33	19.67	11.33	0.00	0.00	0.00	0.00	7.48	0.92	0.82	1.00	1.00	1.00	1.00
	5	29.00	26.00	18.67	0.00	0.00	0.00	0.00	10.52	1.22	0.62	1.00	1.00	1.00	1.00
	6	31.33	28.67	17.33	0.00	0.00	0.00	0.00	11.05	1.00	0.78	1.00	1.00	1.00	1.00
	7	25.67	27.33	19.00	0.00	0.00	0.00	0.00	10.29	-0.77	0.45	1.00	1.00	1.00	1.00
	8	36.33	35.33	0.00	0.00	0.00	0.00	0.00	10.24	0.32	1.75	1.00	1.00	1.00	1.00
	9	18.67	16.67	0.00	0.00	0.00	0.00	0.00	5.05	1.26	1.75	1.00	1.00	1.00	1.00
	10	19.33	15.67	0.00	0.00	0.00	0.00	0.00	5.00	2.24	1.75	1.00	1.00	1.00	1.00
Mean		21.93	20.07	9.40	0.00	0.00	0.00	0.00							
3	1	8.33	4.33	1.33	1.33	2.00	0.00	0.00	2.48	1.29	0.86	0.86	0.76	1.00	1.00
	2	16.00	13.00	3.00	2.67	0.00	0.00	0.00	4.95	0.50	0.83	0.85	1.00	1.00	1.00
	3	26.00	14.67	6.00	7.00	0.00	0.00	0.00	7.67	1.17	0.79	0.75	1.00	1.00	1.00
	4	45.00	40.00	0.00	0.00	0.00	0.00	0.00	12.14	0.30	1.02	1.02	1.00	1.00	1.00

	5	37.33	35.67	0.00	0.00	0.00	0.00	0.00	10.43	0.12	1.02	1.02	1.00	1.00	1.00
	6	69.67	36.00	0.00	0.00	0.00	0.00	0.00	15.10	1.30	1.02	1.02	1.00	1.00	1.00
	7	80.67	32.33	0.00	0.00	0.00	0.00	0.00	16.14	1.61	1.02	1.02	1.00	1.00	1.00
	8	66.33	53.67	0.00	0.00	0.00	0.00	0.00	17.14	0.51	1.02	1.02	1.00	1.00	1.00
	9	56.67	31.00	0.00	0.00	0.00	0.00	0.00	12.52	1.22	1.02	1.02	1.00	1.00	1.00
	10	56.33	29.33	0.00	0.00	0.00	0.00	0.00	12.24	1.29	1.02	1.02	1.00	1.00	1.00
Mean		46.23	29.00	1.03	1.10	0.20	0.00	0.00							
4	1	16.33	15.00	8.33	8.00	7.33	3.00	1.00	8.43	1.42	1.78	0.79	0.81	1.03	1.01
	2	15.67	18.33	14.67	13.00	8.33	6.67	4.00	11.52	-2.96	0.23	0.26	0.69	0.72	0.80
	3	14.33	13.66	12.67	13.33	13.00	10.33	6.00	11.90	0.82	0.42	0.11	0.14	0.35	0.63
	4	16.67	15.33	16.67	12.00	14.00	11.33	0.00	12.28	1.40	0.00	0.43	0.24	0.40	1.08
	5	15.33	12.66	9.67	7.33	6.33	0.00	0.00	7.33	3.03	1.34	0.81	0.87	1.26	1.08
	6	12.67	10.33	8.00	0.00	0.00	0.00	0.00	4.43	3.21	1.34	1.55	1.48	1.26	1.08
	7	15.66	15.33	10.67	0.00	0.00	0.00	0.00	5.95	0.36	1.16	1.55	1.48	1.26	1.08
	8	14.66	13.33	11.67	0.00	0.00	0.00	0.00	5.67	1.58	0.74	1.55	1.48	1.26	1.08
	9	15.33	17.33	8.33	0.00	0.00	0.00	0.00	5.86	-2.27	1.66	1.55	1.48	1.26	1.08
	10	14.67	11.33	9.00	0.00	0.00	0.00	0.00	5.00	3.95	1.41	1.55	1.48	1.26	1.08
Mean		15.13	14.26	10.97	5.37	4.90	3.13	1.10							
5	1	15.00	12.67	11.00	7.67	5.33	3.00	1.00	7.95	0.68	0.69	0.66	0.87	0.96	0.98
	2	16.00	16.00	13.67	12.00	9.33	5.33	3.00	10.76	0.00	0.38	0.34	0.56	0.80	0.85
	3	22.33	20.33	15.67	12.33	15.00	10.33	5.33	14.48	0.39	0.77	0.60	0.44	0.65	0.80
	4	25.67	23.33	27.67	16.33	16.33	15.67	0.00	17.86	0.40	-0.20	0.49	0.49	0.47	1.05
	5	24.67	17.00	17.00	3.67	6.33	0.00	0.00	9.81	1.36	0.80	1.14	1.00	1.20	1.05
	6	21.00	14.33	5.67	0.00	0.00	0.00	0.00	5.86	1.39	1.88	1.34	1.35	1.20	1.05
	7	20.67	16.33	10.00	0.00	0.00	0.00	0.00	6.71	0.91	1.33	1.34	1.35	1.20	1.05
	8	16.00	16.00	7.67	0.00	0.00	0.00	0.00	5.67	0.00	1.34	1.34	1.35	1.20	1.05
	9	21.00	8.00	9.00	0.00	0.00	0.00	0.00	5.43	2.70	1.47	1.34	1.35	1.20	1.05
	10	21.00	12.67	7.00	0.00	0.00	0.00	0.00	5.81	1.73	1.72	1.34	1.35	1.20	1.05
Mean		20.33	15.67	12.43	5.20	5.23	3.43	0.93							

+ 1. Cenchrus cilaris L (Australia); 2. Coelachyrum piercei L.(Local); 3. Cenchrus ciliaris L. (local);
4. Chloris gayana L. Katambora; 5. Chloris gayana L. Callide

Statistical Parameters

	F-Test	LSD (5%)
Salinity	**	1.69
Grass species	**	1.43
Salinity x Grass species	**	3.79
Cuts	**	2.02
Salinity x Cuts	**	5.36
Grass species x Cuts	**	4.53
Salinity x Grass species x Cuts	**	11.98

**- Significant at 0.01 level of probability

Table 5. Mean green matter weight (g/plant) of grass species and their stress susceptibility indexes (Sc.j) based on green matter weight per se

Grass Species +	No. of Cut	Control	3 dS m^{-1}	6 dS m^{-1}	9 dS m^{-1}	12 dS m^{-1}	15 dS m^{-1}	18 dS m^{-1}	Mean	Sc.3 †	Sc.6	Sc.9	Sc.12	Sc.15	Sc.18
1	1	76.50	63.77	22.93	7.33	0.00	0.00	0.00	24.36	1.25	1.22	0.92	1.00	1.00	1.00
	2	112.00	85.73	44.57	9.33	0.00	0.00	0.00	35.95	1.76	1.05	0.93	1.00	1.00	1.00
	3	95.67	93.60	27.00	4.73	0.00	0.00	0.00	31.57	0.16	1.25	0.97	1.00	1.00	1.00
	4	80.57	61.87	17.70	0.00	0.00	0.00	0.00	22.88	1.74	1.36	1.02	1.00	1.00	1.00
	5	123.93	112.63	68.80	0.00	0.00	0.00	0.00	43.62	0.69	0.77	1.02	1.00	1.00	1.00
	6	139.50	88.47	35.87	0.00	0.00	0.00	0.00	37.69	2.75	1.29	1.02	1.00	1.00	1.00
	7	196.63	131.53	51.73	0.00	0.00	0.00	0.00	54.27	2.49	1.28	1.02	1.00	1.00	1.00
	8	154.53	188.57	136.43	0.00	0.00	0.00	0.00	68.50	-1.66	0.20	1.02	1.00	1.00	1.00
	9	86.50	83.00	50.17	0.00	0.00	0.00	0.00	31.38	0.30	0.73	1.02	1.00	1.00	1.00
	10	102.87	104.04	40.51	0.00	0.00	0.00	0.00	35.35	-0.09	1.05	1.02	1.00	1.00	1.00
Mean		116.87	101.32	49.57	2.14	0.00	0.00	0.00							
2	1	49.43	31.70	25.33	0.00	0.00	0.00	0.00	15.21	0.87	0.66	1.00	1.00	1.00	1.00
	2	71.67	41.33	16.70	0.00	0.00	0.00	0.00	18.53	1.03	1.04	1.00	1.00	1.00	1.00
	3	35.27	19.30	18.17	0.00	0.00	0.00	0.00	10.39	1.10	0.66	1.00	1.00	1.00	1.00
	4	28.57	21.80	19.13	0.00	0.00	0.00	0.00	9.93	0.58	0.45	1.00	1.00	1.00	1.00
	5	59.50	38.87	43.87	0.00	0.00	0.00	0.00	20.32	0.84	0.36	1.00	1.00	1.00	1.00
	6	35.33	26.93	5.90	0.00	0.00	0.00	0.00	9.74	0.58	1.13	1.00	1.00	1.00	1.00
	7	55.07	18.97	7.07	0.00	0.00	0.00	0.00	11.59	1.59	1.19	1.00	1.00	1.00	1.00
	8	84.37	52.83	0.00	0.00	0.00	0.00	0.00	19.60	0.91	1.36	1.00	1.00	1.00	1.00
	9	32.03	18.03	0.00	0.00	0.00	0.00	0.00	7.15	1.06	1.36	1.00	1.00	1.00	1.00
	10	63.21	33.13	0.00	0.00	0.00	0.00	0.00	13.76	1.16	1.36	1.00	1.00	1.00	1.00
Mean		51.44	30.29	13.62	0.00	0.00	0.00	0.00							
3	1	58.13	33.80	14.97	10.33	0.00	0.00	0.00	16.75	0.90	0.76	0.82	1.00	1.00	1.00
	2	91.27	67.03	10.47	10.10	0.00	0.00	0.00	25.55	0.57	0.91	0.89	1.00	1.00	1.00
	3	82.30	54.07	5.70	12.13	0.00	0.00	0.00	22.03	0.74	0.96	0.85	1.00	1.00	1.00
	4	106.80	52.27	0.00	0.00	0.00	0.00	0.00	22.72	1.10	1.03	1.00	1.00	1.00	1.00
	5	128.20	71.07	0.00	0.00	0.00	0.00	0.00	28.47	0.96	1.03	1.00	1.00	1.00	1.00
	6	124.33	39.90	0.00	0.00	0.00	0.00	0.00	23.46	1.47	1.03	1.00	1.00	1.00	1.00
	7	219.57	63.63	0.00	0.00	0.00	0.00	0.00	40.46	1.53	1.03	1.00	1.00	1.00	1.00
	8	179.43	125.87	0.00	0.00	0.00	0.00	0.00	43.61	0.65	1.03	1.00	1.00	1.00	1.00
	9	64.38	44.33	0.00	0.00	0.00	0.00	0.00	15.53	0.67	1.03	1.00	1.00	1.00	1.00
	10	86.17	60.82	0.00	0.00	0.00	0.00	0.00	21.00	0.64	1.03	1.00	1.00	1.00	
Mean		114.06	61.28	3.11	3.26	0.00	0.00	0.00							
4	1	78.47	70.37	52.40	32.40	7.93	3.93	1.00	35.21	0.34	0.60	0.69	0.94	0.96	0.99
	2	118.23	109.13	109.90	65.63	15.37	9.67	4.00	61.70	0.25	0.13	0.53	0.91	0.93	0.97
	3	349.30	203.27	141.60	50.53	21.63	9.43	6.00	111.68	1.36	1.08	1.01	0.98	0.99	0.99
	4	237.27	207.23	111.33	69.53	13.13	7.33	0.00	92.26	0.41	0.96	0.84	0.98	0.98	1.01
	5	284.20	165.80	165.57	81.10	17.33	0.00	0.00	102.00	1.35	0.76	0.84	0.98	1.02	1.01
	6	187.37	117.17	58.07	0.00	0.00	0.00	0.00	51.80	1.22	1.25	1.18	1.04	1.02	1.01
	7	237.13	141.03	47.33	0.00	0.00	0.00	0.00	60.79	1.32	1.45	1.18	1.04	1.02	1.01
	8	198.27	157.67	90.97	0.00	0.00	0.00	0.00	63.84	0.66	0.98	1.18	1.04	1.02	1.01
	9	92.30	58.87	34.90	0.00	0.00	0.00	0.00	26.58	1.18	1.13	1.18	1.04	1.02	1.01
	10	165.46	117.33	63.81	0.00	0.00	0.00	0.00	49.51	0.94	1.12	1.18	1.04	1.02	1.01
Mean		194.80	134.79	87.59	29.92	7.54	3.04	1.10							
5	1	95.07	90.20	72.80	29.57	7.43	3.87	1.00	42.85	0.17	0.46	0.83	0.98	0.98	1.00
	2	109.33	124.93	93.30	77.70	12.93	6.33	3.00	61.08	-0.48	0.29	0.35	0.94	0.96	0.98
	3	191.40	158.80	125.47	53.50	27.50	8.73	5.33	81.53	0.57	0.68	0.86	0.91	0.97	0.98
	4	220.37	111.87	114.83	54.03	33.10	11.33	0.00	77.93	1.65	0.94	0.90	0.91	0.97	1.01
	5	198.10	129.57	169.50	52.53	20.00	0.00	0.00	81.39	1.16	0.28	0.88	0.96	1.02	1.01
	6	151.80	73.70	48.83	0.00	0.00	0.00	0.00	39.19	1.73	1.34	1.20	1.07	1.02	1.01
	7	234.23	128.40	55.20	0.00	0.00	0.00	0.00	59.69	1.52	1.50	1.20	1.07	1.02	1.01
	8	196.20	149.13	37.60	0.00	0.00	0.00	0.00	54.70	0.81	1.59	1.20	1.07	1.02	1.01
	9	88.70	74.97	26.26	0.00	0.00	0.00	0.00	27.13	0.52	1.39	1.20	1.07	1.02	1.01
	10	131.76	93.65	51.87	0.00	0.00	0.00	0.00	39.61	0.97	1.19	1.20	1.07	1.02	1.01
Mean		161.70	113.52	79.57	26.73	10.10	3.03	0.93							

+ 1. Cenchrus cilaris L (Australia); 2. Coelachyrum piercei L.(Local); 3. Cenchrus ciliaris L. (local);

4. Chloris gayana L. Katambora; 5. Chloris gayana L. Callide

Statistical Parameters

	F-Test	LSD (5%)
Salinity	**	5.28
Grass species	**	2.77
Salinity x Grass species	**	11.80
Cuts	**	6.31
Salinity x Cuts	**	16.69
Grass species x Cuts	**	14.10
Salinity x Grass species x Cuts	**	37.32

**- Significant at 0.01 level of probability

† - Stress susceptibility index of 'j' (dS), high salinity treatment relative to 'c' (0.80 dS), low salinity treatment (Sc.j)

Table 6. Mean dry matter weight (g/plant) of grass species and their stress susceptibility indexes (Sc.j) based on dry matter weight per se

Grass Species +	No. of Cut	Control	3 dS m^{-1}	6 dS m^{-1}	9 dS m^{-1}	12 dS m^{-1}	15 dS m^{-1}	18 dS m^{-1}	Mean	Sc.3 †	Sc.6	Sc.9	Sc.12	Sc.15	Sc.18
1	1	11.73	8.87	1.45	0.50	0.00	0.00	0.00	3.22	0.93	1.28	0.96	1.00	1.00	1.00
	2	27.83	24.37	13.47	0.30	0.00	0.00	0.00	9.42	0.48	0.75	0.99	1.00	1.00	1.00
	3	22.97	24.33	5.80	0.90	0.00	0.00	0.00	7.71	-0.23	1.09	0.97	1.00	1.00	1.00
	4	34.00	19.13	3.23	0.00	0.00	0.00	0.00	8.05	1.67	1.32	1.00	1.00	1.00	1.00
	5	57.60	49.60	28.23	0.00	0.00	0.00	0.00	19.35	0.53	0.74	1.00	1.00	1.00	1.00
	6	54.67	34.43	14.33	0.00	0.00	0.00	0.00	14.78	1.41	1.08	1.00	1.00	1.00	1.00
	7	57.97	36.83	12.70	0.00	0.00	0.00	0.00	15.36	1.39	1.14	1.00	1.00	1.00	1.00
	8	46.87	41.07	25.17	0.00	0.00	0.00	0.00	16.16	0.47	0.67	1.00	1.00	1.00	1.00
	9	23.28	17.22	6.67	0.00	0.00	0.00	0.00	6.74	0.99	1.04	1.00	1.00	1.00	1.00
	10	27.60	13.20	3.30	0.00	0.00	0.00	0.00	6.30	1.99	1.28	1.00	1.00	1.00	1.00
Mean		36.45	26.91	11.44	0.17	0.00	0.00	0.00							
2	1	5.93	4.63	3.33	0.00	0.00	0.00	0.00	1.99	0.56	0.57	1.00	1.00	1.00	1.00
	2	33.37	16.17	2.50	0.00	0.00	0.00	0.00	7.43	1.31	1.21	1.00	1.00	1.00	1.00
	3	13.10	8.20	5.40	0.00	0.00	0.00	0.00	3.81	0.95	0.77	1.00	1.00	1.00	1.00
	4	5.87	5.27	3.40	0.00	0.00	0.00	0.00	2.08	0.26	0.55	1.00	1.00	1.00	1.00
	5	26.40	18.20	16.37	0.00	0.00	0.00	0.00	8.71	0.79	0.50	1.00	1.00	1.00	1.00
	6	13.83	9.77	0.83	0.00	0.00	0.00	0.00	3.49	0.75	1.23	1.00	1.00	1.00	1.00
	7	11.53	4.13	1.57	0.00	0.00	0.00	0.00	2.46	1.63	1.13	1.00	1.00	1.00	1.00
	8	14.27	9.40	0.00	0.00	0.00	0.00	0.00	3.38	0.87	1.31	1.00	1.00	1.00	1.00
	9	6.52	6.16	0.00	0.00	0.00	0.00	0.00	1.81	0.14	1.31	1.00	1.00	1.00	1.00
	10	11.73	4.67	0.00	0.00	0.00	0.00	0.00	2.34	1.53	1.31	1.00	1.00	1.00	1.00
Mean		14.26	8.66	3.34	0.00	0.00	0.00	0.00							
3	1	48.33	22.67	11.66	8.67	0.97	0.00	0.00	30.77	1.02	0.82	0.85	0.98	1.00	1.00
	2	53.57	16.10	9.83	2.07	0.00	0.00	0.00	27.19	1.34	0.88	0.99	1.00	1.00	1.00
	3	23.66	16.20	7.33	1.47	0.00	0.00	0.00	16.22	0.60	0.75	0.97	1.00	1.00	1.00
	4	19.17	17.60	0.00	0.00	0.00	0.00	0.00	12.26	0.16	1.08	1.03	1.00	1.00	1.00
	5	59.53	26.73	0.00	0.00	0.00	0.00	0.00	28.76	1.06	1.08	1.03	1.00	1.00	1.00
	6	46.77	15.53	0.00	0.00	0.00	0.00	0.00	20.77	1.28	1.08	1.03	1.00	1.00	1.00
	7	56.97	16.43	0.00	0.00	0.00	0.00	0.00	24.47	1.37	1.08	1.03	1.00	1.00	1.00
	8	39.63	32.07	0.00	0.00	0.00	0.00	0.00	23.90	0.37	1.08	1.03	1.00	1.00	1.00
	9	18.47	16.20	0.00	0.00	0.00	0.00	0.00	11.56	0.24	1.08	1.03	1.00	1.00	1.00
	10	24.33	7.33	0.00	0.00	0.00	0.00	0.00	10.56	1.34	1.08	1.03	1.00	1.00	
Mean		39.04	18.69	2.88	1.22	0.10	0.00	0.00							
4	1	36.63	26.27	12.43	5.70	2.37	2.40	1.10	12.41	0.77	1.06	0.95	0.99	0.95	0.98
	2	44.43	35.80	26.33	15.00	10.10	2.77	1.07	19.36	0.53	0.65	0.74	0.82	0.95	0.98
	3	59.77	48.43	43.60	10.53	4.33	2.93	2.03	24.52	0.52	0.43	0.93	0.98	0.97	0.97
	4	87.20	61.47	22.67	12.30	6.90	2.57	0.00	27.59	0.80	1.18	0.97	0.97	0.99	1.01
	5	145.99	63.67	50.17	23.13	9.20	0.00	0.00	41.74	1.54	1.05	0.95	0.99	1.02	1.01
	6	75.57	41.43	22.67	0.00	0.00	0.00	0.00	19.95	1.23	1.12	1.12	1.06	1.02	1.01
	7	53.53	36.60	10.83	0.00	0.00	0.00	0.00	14.42	0.86	1.27	1.12	1.06	1.02	1.01
	8	37.97	28.93	15.35	0.00	0.00	0.00	0.00	11.75	0.65	0.95	1.12	1.06	1.02	1.01
	9	32.70	22.04	5.91	0.00	0.00	0.00	0.00	8.66	0.89	1.31	1.12	1.06	1.02	1.01
	10	28.43	16.53	15.33	0.00	0.00	0.00	0.00	8.61	1.14	0.74	1.12	1.06	1.02	1.01
Mean		60.22	38.12	22.53	6.67	3.29	1.07	0.42							
5	1	41.13	31.53	8.40	5.27	1.70	1.67	1.13	12.98	0.67	1.38	1.00	1.02	0.99	0.98
	2	32.73	33.37	20.63	18.47	8.33	2.76	0.63	16.70	-0.06	0.64	0.50	0.79	0.95	0.99
	3	37.20	31.10	26.77	11.80	7.37	5.43	1.87	17.36	0.47	0.49	0.79	0.85	0.88	0.96
	4	68.10	25.47	21.77	9.93	6.20	6.17	0.00	19.66	1.81	1.18	0.98	0.97	0.94	1.01
	5	108.07	73.20	67.67	16.87	5.77	0.00	0.00	38.80	0.93	0.65	0.97	1.01	1.03	1.01
	6	45.73	24.90	18.77	0.00	0.00	0.00	0.00	12.77	1.31	1.02	1.15	1.07	1.03	1.01
	7	53.10	31.70	12.47	0.00	0.00	0.00	0.00	13.90	1.16	1.33	1.15	1.07	1.03	1.01
	8	38.00	23.70	12.60	0.00	0.00	0.00	0.00	10.61	1.09	1.16	1.15	1.07	1.03	1.01
	9	19.02	21.44	4.60	0.00	0.00	0.00	0.00	6.44	-0.37	1.31	1.15	1.07	1.03	1.01
	10	34.00	15.30	8.00	0.00	0.00	0.00	0.00	8.19	1.59	1.32	1.15	1.07	1.03	1.01
Mean		47.71	31.17	20.17	6.23	2.94	1.60	0.36							

+ 1. Cenchrus cilaris L (Australia); 2. Coelachyrum piercei L.(Local); 3. Cenchrus ciliaris L. (local);
4. Chloris gayana L. Katambora; 5. Chloris gayana L. Callide

Statistical Parameters

	F-Test	LSD (5%)
Salinity	**	1.98
Grass species	**	1.67
Salinity x Grass species	**	4.42
Cuts	**	2.77
Salinity x Cuts	**	5.33
Grass species x Cuts	**	5.28
Salinity x Grass species x Cuts	**	13.97

**- Significant at 0.01 level of probability

† - Stress susceptibility index of 'j' (dS), high salinity treatment relative to 'c' (0.80 dS), low salinity treatment (Sc.j)

Bulk and Basic Seed Multiplication of Indigenous Forage Species

Saleem K Nadaf, Safaa M. Al-Farsi and Saleh A. Al-Hinai
Ministry of Agriculture & Fisheries
Oman

Abstract

Bulk seed multiplication of Cenchrus ciliaris L (UAE Accession No. MAF-120) and basic seed multiplication of Cenchrus ciliaris L (Rumais accession) and Lasiurus hirsutus L. (Rumais accession) were undertaken at Livestock Research Center, Rumais under sprinklers since November- December, 2003. Total seed yields collected through three harvests were 5.150 kg, 1.225 kg and 0.785 kg, respectively in respect of these three species. It has been observed that summer seed crops produced comparatively more seed yield in both the grass species than those did in winter season. These studies clearly indicated that seed can be produced in the Gulf climate of Oman in perennial rangeland grass species like Cenchrus / Lasiurus throughout the year. Problems encountered during seed multiplication and future aspects of research in seed multiplication are highlighted in the report.

Introduction

Sultanate of Oman has a large area of rangelands in the Arabian Peninsula especially in Dhofar Jabal areas of South Oman apart from the ones in the North Oman. More than 100 germplasm of different indigenous forage grass, herb, shrub and tree species have been collected so far which are part of genetic diversity through ages and are under use by the grazing animals. Few (e.g. Lasiurus hirsutus have been investigated for their good quality forage as compared to Rhodes grass besides being capable to emerge under adverse conditions. The seeds of indigenous rangeland forage species will have to be multiplied in large quantities before they are subjected future in research for productivity under irrigation or reseeding depleted rangelands. Further, multiplication of seed of indigenous rangeland forage species has been also one of the mandates of APRP -Phase-II (2.3.3). We had successfully produced seeds of Cenchrus cilaris (UAE accession) and Coelachyrum piercei (UAE accession) during 1999-2002 at Sohar Research Station. Hence, it is planned to carry out bulk seed multiplication of Cenchrus ciliaris L (UAE Accession No. MAF-120) and basic seed multiplication of Cenchrus ciliaris L (Rumais accession) and Lasiurus hirsutus L. (Rumais accession) at Livestock Research Center, Rumais under sprinklers since November- December, 2003.

Materials and Methods

The rhizomes of all the species were transplanted within 5-10 cm depth of sandy soil (Table 1) in 1 m rows spaced 1 m apart in the sprinkler inter-space. The Cenchrus ciliaris L. (UAE accession) was planted in an area of 10 m x 60 m for bulk seed production while other two species were planted in very small area for basic seed production viz. Cenchrus ciliaris L. (Rumais accession) (10 m x 5 m) and Lasiurus hirsutus L. (Rumais accession) (10 m x 8 m). The crop was fertilized with 150 kg N, 150 kg P2O5 and 150 kg K2O per hectare per year in the form of urea, triple super phosphate and potassium sulphate. The entire quantities of potassium and phosphatic fertilizers were applied after the establishment of seedlings while 1/3 N was applied in two split doses- 1/2 N with P and K or after each harvest and remaining 1/2 N at flag leaf emergence. The crop was irrigated daily for 30 minutes till establishment for two weeks and later three times a week each for 1 1/2 hrs during winter and 2 hrs during summer.

The plants of all the species started initiating flowering just within 30 days during January, which were cut at a height of 10 cm from ground level for fodder to allow them produce more tillers and grow vigorously subsequently later for future seed crops. The species were physiologically mature during first week of April 2003 i.e. in about two month's period. The mature seeds were manually collected from each plant by grasping the panicles during mid-April, 2003, when the first harvest was taken up. The second crop came to heading in 30-35 days time and was harvested in the first week of July 2003. The two different accessions of Cenchrus were consciously allowed to mature at different periods of time by keeping appropriate time isolation (25-30 days). The data on seed yield harvested (collected) have been recorded after cleaning the produce.

Results and Discussion

The details of establishment time, plant stand, days to 50% heading and maturity, and seed yield collected (with husk) in each harvest in respect of Cenchrus spp. and Lasiurus hirsutus L. are given in

Tables 2.In case of Cenchrus ciliaris (UAE) a total of 5.850 kg of bulk seed was collected in two harvests while in case of Cenchrus ciliaris (Rumais) basic seed collected was 1.240 kg. A very little basic seed of about 0.280 kg was collected in case Lasiurus hirsutus L (Rumais) as much of the seed was either shattered or blown by the wind just with in the week of harvesting. Germination of 0-5% was observed in each species in the initial germination test carried out using husked seed immediately after harvest while it was between 21 and 26% after four months. This indicated presence of dormancy in the seeds.

Table 1. Valus of some physical and chemical characteristics of the experimental soil at Livestock Research Center, Rumais

CHARACTERISTICS	
PHYSICAL	
Coarse sand (%)	21.70
Fine sand (%)	63.00
Silt (%)	3.90
Clay (%)	11.40
Texture	Sand
CHEMICAL	
EC (15) dS	5.70
pH (15)	7.80
Soluble Cations (meq./100g)	
Na	65.90
K	0.77
Soluble Anions (meq./100g)	
Cl	59.50
N (%)	0.04
Av.P (meq./100g)	15.76

Problems Encountered During Seed Multiplication

1. As both Cenchrus species are non-synchronous in panicle initiation of tillers, shattering of seeds from the panicles of earlier tillers was enormous prior to maturity of panicles of later formed tillers. It was difficult to assess the proper time of harvest of panicles of all the tillers at a time. Either harvesting has to be started as and when earlier formed panicles attain maturity and show the signs of shattering, which would indirectly delay cutting time or it should be resorted to harvest once at a time compromising with loss of some immature seeds of late emerging panicles. Also, there should be some method to collect the shattered seeds from the ground.

2. Although shattering of earlier panicles was less noticed in Lasiurus hirsutus L, tillering appeared to be continuous throughout the growing period with no sign of cessation. This made very difficult to decide the harvesting time. Here also, harvesting at one compromising time was felt necessary.

Table 2. Germination %, Plant Stand, Days to 50% Heading and Harvest, and Seed Yield Collected (kg) at each harvest of two accessions of Cenchrus ciliaris L. and one accession of Lasiurus hirsutus L during the year (2002-2003)

Harvests/ Species	Establishment in Field %	Plant Stand	Days to 50% Heading	Days to Maturity	Seed Yield Collected (Husked) Kg	Germination Test Results (Immediately After Harvest)	Germination Test Results (Four Months After Harvest)
I- Harvest							
C. ciliaris (UAE)	90	85	32	78	3.140	0-5%	26%
C. ciliaris (Rumais)	65	60	27	72	0.825	0-5%	22%
L. hirsutus (Rumais)	72	70	37	70	0.175	0-2%	21%
I- Harvest							
1. *C. ciliaris* (UAE)	-	80	35	80	2.710	0-5%	*-
2. *C. ciliaris* (Rumais)	-	58	32	70	0.415	0-3%	-
3. *L. hirsutus* (Rumais)	-	68	38	71	0.075	0-2%	-
Total Seed Yield (kg)							
1. *C. ciliaris* (UAE)	-	80	37	82	5.850	-	-
2. *C. ciliaris* (Rumais)	-	58	33	71	1.240	-	-
3. *L. hirsutus* (Rumais)	-	68	37	72	0.280	-	-

* - Germination tests will be carried out during November-December 2003

Effect of Inter-row and Inter-plant Spacing on Seed Yield and its related Traits of Indigenous Rangeland and Forage Grass Species grown under Drips

Saleem K Nadaf, Safaa M. Al-Farsi and Saleh A. Al-Hinai
Ministry of Agriculture & Fisheries
Oman

Abstract

Two indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE) and Coelachyrum piercii L.(UAE) collected under ICARDA- APRP Phase- I were investigated under ICARDA- APRP Phase-II from April-May 2001 to July-August 2003 spanning eight harvests, for their response to varying levels of inter-row (50 and 100 cm) and inter plant spacing (25, 50 and 100 cm) along with perennial popular perennial forage grass species, Rhodes grass (Chloris gayana L.cv. Katambora) at Live Stock Research Station, Rumais. There existed differential expression of the traits such as plant stand, plant height, number of tillers, number of panicles and seed yield (with husk) in the grass species under varying inter-row and inter-plant spacing in different harvests. The seed yields were significantly higher in all the grass species in the progressive harvests after one year. Among the grass species, Chloris gayana (219.00 to 578.00 and 240.78 to 734.61 kg/ha at 50 and 100 cm row spacings, respectively) produced significantly higher seed yield than Cenchrus ciliaris (306.11 to 472.33 and 359.00 to 529.12 kg/ha at 50 and 100 cm row spacings respectively). Coelachyrum piercei produced lowest seed yield (128.89 to 282.75 and 161.05 to 340.53 kg/ha at 50 and 100 cm row spacings, respectively) as compared to other grass species in all the harvests The mean grass seed yield irrespective of species was higher in the fifth (404.19 kg/ha at 50 cm row spacing and 458.64 kg at 100 cm row spacing) and sixth harvests (412.74 kg/ha at 50 cm row spacing and 501.02 kg at 100 cm row spacing) than the preceding and succeeding harvests. In almost all the harvests, 100 cm row spacing gave significantly higher yield than 50 cm spacing. In at least three harvests at 50 cm row spacing and in as many as six harvests at 100 cm row spacing, wider inter-plant spacing significantly out yielded ($p<0.05$) narrow inter-plant spacing. Among the grass species at 50 cm row spacing irrespective of interplant spacings, Chloris gayana produced significantly higher yield in at least two harvests taken mostly in winter (408.78 to 578.05 kg/ha, $p<0.05$) and in one harvest taken in summer (524.89 kg/ha, $p<0.05$) than Cenchrus ciliaris while Cenchrus ciliaris outyielded Chloris gayana with 306.11 kg/ha ($p<0.05$) only in the first harvest taken during summer. Similarly at 100 cm row spacing, Chloris gayana produced significantly higher yield in three harvests taken in winter (519.50 to 746.90 kg/ha, $p<0.05$) and in two harvests taken during summer (345.50 to 533.33 kg/ha, $p<0.05$) than Cenchrus ciliaris while Cenchrus ciliaris outyielded Chloris gayana in two harvests (493.33 to 550.49 kg/ha, $p<0.05$) taken only during summer.

Introduction

Sultanate of Oman has a large area of rangelands in the Arabian Peninsula especially in Dhofar Jabel areas of South Oman apart from the ones in the North Oman. More than 50 germplasm of different indigenous forage species have been collected under APRP -Phase I, which are part of genetic diversity through ages and are under use by the grazing animals. Few (e.g. Coelachyrum piercei have been investigated for their good quality forage as compared to Rhodes grass besides being capable to emerge under adverse conditions. The productivity and availability of seeds are the important factors in case of any grass species (Chatterjee and Das, 1989 Loch and Clark, 2000). It is more so important because the grass species have been evolved as perennials for vegetative forage yield and as such they are shy yielders with very low seed productivity. In order to popularize the indigenous rangeland grass species for cultivation or re-vegetation of barren rangelands, seed production methods have to be standardized for specific irrigation system towards maximization of seed yield. In light of the above, the investigations have been conducted from April-May 2001 to July-August 2003 under ICARDA-APRP Phase –II towards maximizing seed yield of indigenous rangeland and forage species by modifying plant densities through inter-row and inter-plant spacing under drips. This report discusses results of the investigations spanning eight seed harvests.

Materials and Methods

The grass species 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 (Peacock et al., 2000) and Rhodes grass (Chloris gayana Kunth.)- Katambora. The trial was laid in modified three factor RCBD with three replications involving three grass species as first factor, two inter-row spacing (50 cm and 100 cm) as second factor and three inter-plant spacing (25 cm, 50 cm and 100 cm) as third factor under drips at Livestock Research Station, Rumais. There were three and two four-meter rows per plot respectively at 50 and 100-cm spacing.

Four to five seeds were sown just within 2.5 cm depth of sandy soil (Table 1) at drip points. 10-15 granules of systemic insecticide, Carbofuron (Furadon) were scattered around each hill to protect seeds from ants. The crop was fertilized with 150 kg N, 150 kg P2O5 and 150 kg K2O per hectare per year in the form of urea, triple super phosphate and potassium sulfate. The entire quantities of potassium and phosphate fertilizers were applied after the establishment of seedlings while 1/3 N was applied in two split doses- 1/2 N with P and K or after each harvest and remaining 1/2 N at flag leaf emergence. Eight seed harvests were taken up during the period of experimentation.

The observations on plant stand (0-10 scale (0-100%)) plant height (cm), number of tillers/ plant, number of panicles per plant and seed yield (with husk) (g) per plot (1m x 4m) were recorded at harvest. The data on above traits were subjected to ANOVA considering harvests, inter-row spacing, inter-plant spacing and grass species as factors using MSTAT-C computer program (Gomez and Gomez, 1984). The samples of bulk seed of each harvest had been subjected for laboratory germination test (after about five months, as there was very less germination (0-1.5 %) immediately (about one week) after harvest)), with five replications following the procedure suggested by Agrawal (1980) using Top of Paper (TP) method of germination.

Table 1. Valus of some physical and chemical characteristics of the experimental soil at Livestock Research Center, Rumais

CHARACTERISTICS	
PHYSICAL	
Coarse sand (%)	21.70
Fine sand (%)	63.00
Silt (%)	3.90
Clay (%)	11.40
Texture	Sand
CHEMICAL	
EC (15) dS	5.70
pH (15)	7.80
Soluble Cations (meq./100g)	
Na	65.90
K	0.77
Soluble Anions (meq./100g)	
Cl	59.50
N (%)	0.04
Av.P (meq./100g)	15.76

Results and Discussion

The results of the investigations indicated the existence of differential expression of the traits in the three grass species under varying inter-row and inter-plant spacing in different harvests.(Tables2 to 7).

Plant Stand (%)

In respect of plant stand only the main effect of grass species and its interaction effect with harvests were highly significant ($p<0.01$) (Table 2) indicating differential expression of grass species leading to persistence of plant stand in subsequent harvests. There was no significant reduction ($p> 0.05$) in the mean plant stands over inter-plant spacings of Chloris gayana and Cenchrus ciliaris (86.70%) up to eight harvest at both inter-row spacings of 50 cm (93.50% and 86.70%) and 100 cm (94.60% and 89.90%) from their initial plant stands (Table 2). The plant stand of Coelachyrum piercei got significantly deteriorated in subsequent cuts after IV harvest in all the plots of different inter-row and interplant spacings. The mean plant stands over inter-plant spacings of Coelachyrum piercei were reduced to 49.10% and 61.30% from initial plant stands of 92.20% and 93.90% respectively at 50 cm and 100 cm row spacings. In general wider inter-row or inter-plant spacing of 100 cm in general had comparatively but not significantly more plant stand narrow inter-row or inter-plant spacings (Table2).

Plant Height

In respect of plant height all the effects but two of 2-factor interactions viz. inter-row x interplant spacing and inter-plant spacing x grass species and one of 3-factor interactions viz. harvests x row spacing x grass species, were significant to highly significant ($p<0.05$)(Table 3). Among the grass species both Cenchrus ciliaris and Chloris gayana had recorded higher plant height of over 100 cm as compared to Coelachyrum piercei that recorded low plant height in most harvests. Cenchrus ciliaris had significantly high mean plant height ($p<0.05$) ranging from 105.87 to 126.78 cm at 100 cm row spacing as compared to that ranged between 101.33 and 120.82 cm at 50-cm row spacing in different harvests. Conversely, Chloris gayana appeared to show significantly greater ($p<0.05$) height at 50 cm row spacing (94.03 to 119.56 cm) than at wider 100-cm row spacing (88.19 to 118.13 cm) in different harvests. The mean plant height at 100 row- spacing (88.19 to 104.94 cm) was significantly higher ($p< 0.05$) than that at 50-cm row spacing (84.37 to 104.73) in at least six harvests. The mean plant height at 100 cm plant-spacing was significantly higher than that at 50 cm or 25 cm plant spacing in six harvests at 50 cm row-spacing (95.99 to 106.79 cm) and in four harvests (94.51 to 110.96 cm) at 100 cm row-spacing (Table 3).

Number of Tillers / Plant

In respect of number of tillers, main effects of all factors and effects of three 2-factor interactions viz. harvests x inter-row spacing, inter-row spacing x inter-plant spacing and inter-row spacing x grass species and that of one 3-factor interactions viz. inter-row spacing x inter-plant spacing x grass species were highly significant ($p<0.01$) (Table 4). Among the grass species Cenchrus ciliaris from the beginning and Chloris gayana later after first harvest had recorded high number of tillers as compared to Coelachyrum piercei that recorded low number of tillers in the later harvests. Cenchrus ciliaris had significantly high number of tillers ranging from 97.49 to 128.74 at 100 cm row-spacing as compared to that ranged between 94.97 and 114.83 at 50 cm row-spacing in different harvests. Similarly, Chloris gayana had also significantly high number of tillers ranging from 53.71 to 142.01 at 100 cm row-spacing as compared to that ranged between 51.92 and 114.73 at 50 cm row-spacing in different harvests. Conversely, in case of Coelachyrum piercei except in the first two harvests, in all subsequent harvests it produced significantly less number of tillers ($p<0.05$) as compared to other two grass species. The mean number of tillers at 100 row- spacing (79.28 to 123.88) was significantly higher ($p< 0.05$) than that at 50-cm row spacing (77.35 to 105.71) in at least six harvests. The mean number of tillers at 100-cm plant spacing was significantly higher than that at 50 cm or 25 cm plant spacing at both row-spacings in at least six different harvests (Table 4).

Number of Panicles/ Plant

In respect of number of panicles, effects of main factors and effects of three 2- factor interactions viz. inter-row spacing x inter-plant spacing, harvests x grass species and inter-plant spacing x grass species were highly significant ($p<0.01$) (Table 5). Among the grass species Chloris gayana and Cenchrus ciliaris had produced more number of panicles as compared to Coelachyrum piercei especially after first and subsequent harvests. Coelachyrum piercei produced low number of panicles in the later harvests. Chloris gayana had significantly high number of panicles ranging from 71.20 to 93.22 at 100 cm row-spacing as compared to that ranged between 65.72 and 80.60 at 50 cm row-spacing in different harvests after the first. Similarly, Cenchrus ciliaris had also significantly high number of panicles ranging from 64.69 to 93.59 at 100 cm row-spacing as compared to that ranged between 57.41 and 79.18 at 50 cm row-spacing in different harvests after the first. Conversely, in case of Coelachyrum piercei except in the first two harvests, in all subsequent harvests it produced significantly less number of panicles ($p<0.05$) as compared to other two grass species. The mean number of panicles at 100 row- spacing (52.19 to 84.23) was significantly higher ($p< 0.05$) than that at 50-cm row spacing (40.21 to 72.06) in different six harvests. The mean number of panicles at 100-cm plant spacing was significantly higher than that at 50 cm or 25 cm plant spacing at both row-spacings in almost all harvests after the first (Table 5).

Seed Yield (With Husk)/ Ha

In respect of seed yield (with husk), all the main effects and all the effects of interactions except that of inter-row spacing x inter-plant spacing and inter-row spacing x grass species were significant to highly significant ($p<0.05$) (Table 6). The seed yields were significantly higher in all the grass species in the progressive harvests after one year. Among the grass species, Chloris gayana (219.00 to 578.00 and 240.78 to 734.61 kg/ha at 50 and 100 cm row spacings, respectively) produced significantly higher seed yield than Cenchrus ciliaris (306.11 to 472.33 and 359.00 to 529.12 kg/ha at 50 and 100 cm row spacings respectively). Coelachyrum piercei produced lowest seed yield (128.89 to 282.75 and 161.05 to 340.53 kg/ha at 50 and 100 cm row spacings, respectively) as compared to other grass species in all the harvests The mean grass seed yield irrespective of species was higher in the fifth (404.19 kg/ha at 50 cm row spacing and 458.64 kg at 100 cm row spacing) and sixth harvests (412.74 kg/ha at 50 cm row spacing and 501.02 kg at 100 cm row spacing) than the preceding and succeeding harvests. In almost all the harvests, 100 cm row spacing gave significantly higher yield than 50 cm spacing. In at least three harvests at 50 cm row spacing and in as many as six harvests at 100 cm row spacing, wider inter-plant spacing significantly out yielded ($p<0.05$) narrow inter-plant spacing. Among the grass species at 50 cm row spacing irrespective of interplant spacings, Chloris gayana produced significantly higher yield in at least two harvests taken mostly in winter (408.78 to 578.05 kg/ha, $p<0.05$) and in one harvest taken in summer (524.89 kg/ha, $p<0.05$) than Cenchrus ciliaris while Cenchrus ciliaris outyielded Chloris gayana with 306.11 kg/ha ($p<0.05$) only in the first harvest taken during summer. Similarly at 100 cm row spacing, Chloris gayana produced significantly higher yield in three harvests taken in winter (519.50 to 746.90 kg/ha, $p<0.05$) and in two harvests taken during summer (345.50 to 533.33 kg/ha, $p<0.05$) than Cenchrus ciliaris while Cenchrus ciliaris outyielded Chloris gayana in two harvests (493.33 to 550.49 kg/ha, $p<0.05$) taken only during summer (Table 6).

Germination %

Table 7 shows germination % of bulk seed samples of three grass species of seven harvests, recorded after about five months of each harvest. In general, germination % of the grass species appeared to be low. Among the grass species, Cenchrus ciliaris recorded highest germination % ranging between 26.25 % and 29.05 %, followed by Coelachyrum piercei (19.35 to 26.32%) and Chloris gayana (17.36 to 22.75% This is attributed to inclusion of immature seed of late formed panicles, possible loss of viable good quality seed due to shattering and possible loss viability of fraction of seed due to delay in harvesting the seed. This is not unexpected, as harvesting good quality seed is a major problem being faced by grass seed growers. 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).In expanding the cultivation of perennial forage species, limited supply of good seeds is an important constraint, which is also relevant to under-exploited indigenous rangeland pasture species. In developing better technology for seed production of pasture species, agronomic practices need to be devised which assist the seed producers to realize the yield potential of the rangeland pasture species. The preliminary results of the present investigation up to eight harvests have provided indications that the grass species behave differentially for their optimum performance in varying inter-row and inter-plant spacing. This is particularly true for seed yield (Table 6). Wider inter-row spacing has significantly ($p<0.05$) influenced formation of more panicles and higher seed yield irrespective of grass species (Table 5 and 6). In the case of perennial pasture species, low plant density at establishment turns out to higher plant densities later on. The low plant density in the beginning would lead to high percentage fertility of tillers (Chatterjee and Das, 1989). In case of grass species like Cenchrus ciliaris and Rhodes grass (Chloris gayana), however, seed yields were dependent of inter-row spacing in most of the harvests (Table 6). Boonman (1972) observed independence of row spacing between 25 to 100 cm in Chloris gayana cv. Mbarara with the seed yield. Chatterjee and Das (1989), however, opined that the seed crop sown wider spacing produce more seed yield in the grass species like Cenchrus ciliaris. The seed yield (with husk) levels of Chloris gayana and Cenchrus ciliaris found in the present study are comparable with the seed yield levels reported elsewhere. Skerman and Rivorose (1989) reported clean (naked) seed yield of 100-650 and 10-60 kg/ha in respect of Chloris gayana and Cenchrus ciliaris, respectively and Chatterjee and Das (1989) reported seed yield (naked) of 500 to 600 and 100-200 kg/ha ha in respect of Chloris gayana and Cenchrus ciliaris, respectively.

Conclusions

The grass species produced higher seed yield (with husk) under wider row (100 cm) spacing than that under narrow row (50 cm). Chloris gayana produced highest mean seed yield (over eight harvests) (475.99 kg/ha under 100 cm and 413.67 kg/ha under 50 cm row spacing) followed by Cenchrus cilaris (449.63 kg/ha under 100 cm and 384.83 kg/ha under 50 cm row spacing) and Coelachyrum piercei (254.62 kg/ha under 100 cm and 210.35 kg/ha under 50 cm row spacing).

Acknowledgements

We are grateful to the Director General of Agriculture, Assistant DG of Agriculture Research & Extension and Director of Agriculture Production Research Center, for their assistance and encouragement in conducting experiments. APRP-ICARDA is gratefully acknowledged for financial and technical assistance.

References

Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Pub. Co. 449-474p.

Boonman. 1972. In Chatterjee, B.N. and Das, P.K. 1989. Forage crop production- Principles and Practices. Oxford and IBH Pub. Co. Pvt. Ltd. New Delhi. 450 p.

Chatterjee, B.N. and Das, P.K. 1989. Forage crop production- Principles and Practices. Oxford and IBH Pub. Co. Pvt. Ltd. New Delhi. 450 p.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. Second Ed. The International Rice Research Institute, Philippines.

Loch, D.S. and Clark, M. 2000. Production, harvesting and processing of native grass and herbaceous legume seeds The realisty and the challenge. First Regional Technical Coordination Meeting (RTCM). APRP Phase II. Dubai, UAE. 16-18 October 2000.

Peacock, J.M., Ferguson, M.E., Alhadrami, G.A., McCann, I.R., Al Hajoj, A., Saleh, A. and Karnik, R. 2000. Conservation through utilization-a case study of the indigenous forage grasses of the Arabian Peninsula. Paper presented at the International Conference on the Conservation of Biodiversity in the Arid Regions. Kuwait. March 27-29, 2000.

Table 2. Means of plant stand (0-10) of two indigenous rangeland forage grass species and Rhodes grass under two inter-row and three-interplant spacing in eight harvests

Harvest	Row Spacing	50 cm				100 cm			
	Inter-plant spacing	*Cenchrus ciliaris L* (local)	*Coelachyrum piercei L* (local)	*Chloris gayana L.* cv. Katambora	Mean (Inter-plant)	*Cenchrus ciliaris L* (local)	*Coelachyrum piercei L* (local)	*Chloris gayana L.* cv. Katambora	Mean (Inter-plant)
1	25 cm	9.47	9.50	9.83	9.60	9.17	9.50	9.67	9.44
Sep-Oct 01	50 cm	8.67	8.33	9.50	8.83	8.83	8.83	9.50	9.06
	100 cm	9.83	9.83	9.83	9.83	9.50	9.83	9.83	9.72
	Mean (grass species)	9.32	9.22	9.72		9.17	9.39	9.67	
	Row Mean		9.42				9.41		
2	25 cm	9.33	8.57	9.83	9.24	9.33	9.17	9.67	9.39
Jan-Feb 02	50 cm	9.17	8.57	9.50	9.08	9.33	8.50	9.50	9.11
	100 cm	9.60	9.33	9.83	9.59	9.50	9.33	9.83	9.56
	Mean (grass species)	9.37	8.82	9.72		9.39	9.00	9.67	
	Row Mean		9.30				9.35		
3	25 cm	9.33	8.50	9.83	9.22	9.33	9.17	9.67	9.39
Apr-May 02	50 cm	9.08	8.50	9.50	9.03	9.33	8.50	9.50	9.11
	100 cm	9.42	9.33	9.83	9.53	9.50	9.33	9.83	9.56
	Mean (grass species)	9.28	8.78	9.72		9.39	9.00	9.67	
	Row Mean		9.26				9.35		
4	25 cm	9.17	8.17	9.83	9.06	9.33	8.73	9.67	9.24
Jul-Aug 02	50 cm	9.17	8.33	9.50	9.00	9.17	8.17	9.50	8.94
	100 cm	9.42	9.00	9.83	9.42	9.25	8.83	9.83	9.31
	Mean (grass species)	9.25	8.50	9.72		9.25	8.58	9.67	
	Row Mean		9.16				9.16		
5	25 cm	9.033	6.167	9.833	8.34	9.45	8	9.667	9.04
Oct-Nov 02	50 cm	9	6.333	9.5	8.28	9.083	7.267	9.5	8.62
	100 cm	9.167	7	9.833	8.67	9.133	8.167	9.833	9.04
	Mean (grass species)	9.07	6.50	9.72		9.22	7.81	9.67	
	Row Mean		8.43				8.90		
6	25 cm	9	5.5	9.833	8.11	9.367	6.667	9.667	8.57
Jan-Feb 03	50 cm	8.917	5.333	9.5	7.92	9	7	9.5	8.50
	100 cm	9.167	6	9.833	8.33	9.1	7.667	9.833	8.87
	Mean (grass species)	9.03	5.61	9.72		9.16	7.11	9.67	
	Row Mean		8.12				8.64		
7	25 cm	8.9	5	9.417	7.77	9.133	5.833	9.5	8.16
Apr-May 03	50 cm	8.833	5.167	9.25	7.75	9	6.333	9.383	8.24
	100 cm	8.833	5.333	9.417	7.86	9	7.1	9.5	8.53
	Mean (grass species)	8.86	5.17	9.36		9.04	6.42	9.46	
	Row Mean		7.79				8.31		
8	25 cm	8.9	4.767	9.417	7.69	8.983	5.633	9.5	8.04
Jul-Aug 03	50 cm	36	4.9	9.25	16.72	9	6.133	9.383	8.17
	100 cm	8.75	5.133	9.417	7.77	9	6.633	9.5	8.38
	Mean (grass species)	17.88	4.93	9.36		8.99	6.13	9.46	
	Row Mean		10.73				8.20		
Mean (grass species) over harvests and inter-plant spacing		10.26	7.19	9.63		9.20	7.93	9.62	

Harvest x Grass species	**	2.55
Inter-row spacing x Grass species	NS	-
Harvest x Inter-row spacing x Grass species	NS	-
Inter-plant spacing x Grass species	NS	-
Harvest x Inter-plant spacing x Grass species	NS	-
Inter-row spacing x Inter-plant spacing x grass species	NS	-
Harvest x Inter-row spacing x Inter-plant spacing x grass species	NS	-
CV (%)		43.54

<u>**Statistical Parameters**</u>

	F-Test	LSD (5%)
Harvest	NS	-
Inter-row spacing	NS	-
Harvest x Inter-row spacing	NS	-
Inter-plant spacing	NS	-
Harvest x Inter-plant spacing	NS	-
Inter-row spacing x Inter-plant spacing	NS	-
Harvest x Inter-row spacing x Inter-plant spacing	NS	-
Grass species	**	0.90

Table 3. Means of plant height (cm) of two indigenous rangeland forage grass species and Rhodes grass under two inter-row and three-interplant spacing in eight harvests

Harvest	Row Spacing	50 cm				100 cm			
	Inter-plant spacing	Cenchrus ciliaris L (local)	Coelachyrum piercei L (local)	Chloris gayana L. cv. Katambora	Mean (Inter-plant)	Cenchrus ciliaris L (local)	Coelachyrum piercei L (local)	Chloris gayana L. cv. Katambora	Mean (Inter-plant)
1 Sep-Oct 01	25 cm	101.23	57.23	92.33	83.60	118.33	66.33	67.57	84.08
	50 cm	107.13	62.67	89.33	86.38	109.10	73.67	110.00	97.59
	100 cm	124.90	72.57	100.43	99.30	101.00	66.33	87.00	84.78
	Mean (grass species)	111.09	64.16	94.03		109.48	68.78	88.19	
	Row Mean		89.76				88.81		
2 Jan-Feb 02	25 cm	103.33	66.33	96.43	88.70	113.33	76.00	96.23	95.19
	50 cm	106.67	64.00	97.87	89.51	112.33	77.00	108.40	99.24
	100 cm	112.33	71.67	103.97	95.99	119.00	74.80	117.43	103.74
	Mean (grass species)	107.44	67.33	99.42		114.89	75.93	107.36	
	Row Mean		91.40				99.39		
3 Apr-May 02	25 cm	104.50	76.33	104.97	95.27	104.63	84.33	99.90	96.29
	50 cm	104.23	72.33	109.43	95.33	111.30	94.33	107.77	104.47
	100 cm	112.40	81.67	120.27	104.78	114.80	96.17	121.90	110.96
	Mean (grass species)	107.04	76.78	111.56		110.24	91.61	109.86	
	Row Mean		98.46				103.90		
4 Jul-Aug 02	25 cm	106.17	77.23	111.80	98.40	115.50	74.67	109.23	99.80
	50 cm	135.93	71.20	119.90	109.01	119.43	68.83	115.93	101.40
	100 cm	120.13	73.27	126.97	106.79	127.77	72.40	129.23	109.80
	Mean (grass species)	120.74	73.90	119.56		120.90	71.97	118.13	
	Row Mean		104.73				103.67		
5 Oct-Nov 02	25 cm	102.67	57.23	98.90	86.27	117.37	65.83	85.33	89.51
	50 cm	112.90	55.20	89.70	85.93	101.33	62.43	99.30	87.69
	100 cm	94.10	53.37	95.23	80.90	98.90	66.93	96.27	87.37
	Mean (grass species)	103.22	55.27	94.61		105.87	65.07	93.63	
	Row Mean		84.37				88.19		
6 Jan-Feb 03	25 cm	98.67	59.60	103.30	87.19	110.43	68.57	96.17	91.72
	50 cm	97.67	59.13	93.63	83.48	107.57	66.60	92.43	88.87
	100 cm	107.67	57.57	90.90	85.38	114.00	68.97	100.57	94.51
	Mean (grass species)	101.33	58.77	95.94		110.67	68.04	96.39	
	Row Mean		85.35				91.70		
7 Apr-May 03	25 cm	111.83	63.43	106.43	93.90	120.77	72.73	123.37	105.62
	50 cm	120.63	63.90	111.53	98.69	124.17	70.80	113.87	102.94
	100 cm	130.00	60.63	101.57	97.40	131.40	72.90	104.03	102.78
	Mean (grass species)	120.82	62.66	106.51		125.44	72.14	113.76	
	Row Mean		96.66				103.78		
8 Jul-Aug 03	25 cm	109.67	60.33	109.67	93.22	121.33	72.67	125.67	106.56
	50 cm	118.00	61.00	114.33	97.78	126.33	70.33	114.67	103.78
	100 cm	126.33	57.33	105.67	96.44	132.67	72.33	108.47	104.49
	Mean (grass species)	118.00	59.56	109.89		126.78	71.78	116.27	
	Row Mean		95.81				104.94		
Mean (grass species) over harvests and inter-plant spacing		111.21	64.80	103.94		115.53	73.17	105.45	

Grass species	*	1.75
Harvest x Grass species	**	4.95
Inter-row spacing x Grass species	**	2.47
Harvest x Inter-row spacing x Grass species	NS	-
Inter-plant spacing x Grass species	NS	-
Harvest x Inter-plant spacing x Grass species	**	8.56
Inter-row spacing x Inter-plant spacing x grass species	**	4.28
Harvest x Inter-row spacing x Inter-plant spacing x grass species	*	12.10
CV (%)		7.93

Statistical Parameters

	F-Test	**LSD (5%)**
Harvest	**	2.85
Inter-row spacing	**	1.43
Harvest x Inter-row spacing	**	4.03
Inter-plant spacing	*	1.75
Harvest x Inter-plant spacing	**	4.94
Inter-row spacing x Inter-plant spacing	NS	-
Harvest x Inter-row spacing x Inter-plant spacing	*	6.99

Table 4. Means of number of tillers/ plant of two indigenous rangeland forage grass species and Rhodes grass under two inter-row and three-interplant spacing in eight harvests

Harvest	Row spacing	50 cm				100 cm			
	Inter-plant spacing	*Cenchrus ciliaris* L (local)	*Coelachyrum piercei* L (local)	*Chloris gayana* L. cv. Katambora	Mean (Inter-plant)	*Cenchrus ciliaris* L (local)	*Coelachyrum piercei* L (local)	*Chloris gayana* L. cv. Katambora	Mean (Inter-plant)
1 Sep-Oct 01	25 cm	125.10	121.57	57.43	101.37	71.43	81.33	60.57	71.11
	50 cm	76.80	116.57	40.47	77.94	109.67	105.87	53.00	89.51
	100 cm	83.00	78.33	57.87	73.07	111.37	91.30	47.57	83.41
	Mean (grass species)	94.97	105.49	51.92		97.49	92.83	53.71	
	Row Mean		84.13				81.34		
2 Jan-Feb 02	25 cm	96.43	79.90	88.97	88.43	95.23	110.97	129.43	111.88
	50 cm	97.87	123.13	92.63	104.54	98.97	121.43	131.77	117.39
	100 cm	97.30	108.03	113.67	106.33	128.10	127.90	138.90	131.63
	Mean (grass species)	97.20	103.69	98.42		107.43	120.10	133.37	
	Row Mean		99.77				120.30		
3 Apr-May 02	25 cm	117.57	86.63	105.67	103.29	115.23	97.23	137.13	116.53
	50 cm	113.30	83.30	110.43	102.34	118.43	102.27	141.63	120.78
	100 cm	113.63	92.77	128.10	111.50	144.47	111.23	147.27	134.32
	Mean (grass species)	114.83	87.57	114.73		126.04	103.58	142.01	
	Row Mean		105.71				123.88		
4 Jul-Aug 02	25 cm	99.43	83.80	96.20	93.14	118.50	90.30	100.37	103.06
	50 cm	101.03	77.80	98.80	92.54	124.64	86.97	118.03	109.88
	100 cm	102.87	83.10	106.77	97.58	131.37	90.87	121.57	114.60
	Mean (grass species)	101.11	81.57	100.59		124.83	89.38	113.32	
	Row Mean		94.42				109.18		
5 Oct-Nov 02	25 cm	125.57	67.13	66.77	86.49	74.10	82.03	61.47	72.53
	50 cm	86.30	67.33	54.63	69.42	98.20	76.83	61.63	78.89
	100 cm	90.47	70.93	67.03	76.14	122.33	80.83	56.07	86.41
	Mean (grass species)	100.78	68.47	62.81		98.21	79.90	59.72	
	Row Mean		77.35				79.28		
6 Jan-Feb 03	25 cm	100.33	63.63	93.57	85.84	100.17	78.40	130.23	102.93
	50 cm	102.23	64.53	97.37	88.04	103.07	73.23	133.90	103.40
	100 cm	101.77	67.60	114.23	94.53	126.00	76.00	141.10	114.37
	Mean (grass species)	101.44	65.26	101.72		109.74	75.88	135.08	
	Row Mean		89.47				106.90		
7 Apr-May 03	25 cm	105.90	58.63	86.57	83.70	123.57	72.13	109.77	101.82
	50 cm	104.87	59.80	90.50	85.06	126.77	68.83	116.83	104.14
	100 cm	110.53	62.43	93.50	88.82	135.90	71.73	136.40	114.68
	Mean (grass species)	107.10	60.29	90.19		128.74	70.90	121.00	
	Row Mean		85.86				106.88		
8 Jul-Aug 03	25 cm	104.33	62.00	91.83	86.06	122.67	77.00	109.47	103.04
	50 cm	97.67	62.67	88.63	82.99	115.67	71.67	119.10	102.14
	100 cm	101.33	64.67	95.10	87.03	124.00	74.30	130.00	109.43
	Mean (grass species)	101.11	63.11	91.86		120.78	74.32	119.52	
	Row Mean		85.36				104.87		
Mean (grass species) over harvests and inter-plant spacing		102.32	79.43	89.03		114.16	88.36	109.72	

Grass species	**	3.33
Harvest x Grass species	**	9.41
Inter-row spacing x Grass species	**	4.70
Harvest x Inter-row spacing x Grass species	NS	-
Inter-plant spacing x Grass species	NS	-
Harvest x Inter-plant spacing x Grass species	NS	-
Inter-row spacing x Inter-plant spacing x grass species	**	8.15
Harvest x Inter-row spacing x Inter-plant spacing x grass species	NS	-
CV (%)	14.83	

Statistical Parameters

	F-Test	LSD (5%)
Harvest	**	5.43
Inter-row spacing	**	2.72
Harvest x Inter-row spacing	**	7.68
Inter-plant spacing	**	3.33
Harvest x Inter-plant spacing	NS	-
Inter-row spacing x Inter-plant spacing	**	4.70
Harvest x Inter-row spacing x Inter-plant spacing	NS	-

Table 5. Means of number of panicles/ plant of two indigenous rangeland forage grass species and Rhodes grass under two inter-row and three inter-plant spacing in eight harvests

Harvest	Row Spacing	50 cm				100 cm			
	Inter-plant spacing	Cenchrus ciliaris L (local)	Coelachyrum piercei L (local)	Chloris gayana L. cv. Katambora	Mean (Inter-plant)	Cenchrus ciliaris L (local)	Coelachyrum piercei L (local)	Chloris gayana L. cv. Katambora	Mean (Inter-plant)
1 Sep-Oct 01	25 cm	25.23	69.00	26.67	40.30	38.23	76.07	6.33	40.21
	50 cm	15.97	107.13	10.17	44.42	29.12	96.90	25.23	50.42
	100 cm	18.61	73.63	15.43	35.89	78.67	87.79	31.33	65.93
	Mean (grass species)	19.94	83.26	17.42		48.67	86.92	20.97	
	Row Mean		40.21				52.19		
2 Jan-Feb 02	25 cm	62.97	43.03	67.77	57.92	58.00	67.27	84.33	69.87
	50 cm	55.23	53.97	68.47	59.22	58.63	74.57	87.63	73.61
	100 cm	54.03	66.77	76.97	65.92	77.43	80.07	88.30	81.93
	Mean (grass species)	57.41	54.59	71.07		64.69	73.97	86.76	
	Row Mean		61.02				75.14		
3 Apr-May 02	25 cm	77.87	57.70	74.90	70.16	79.53	61.73	89.43	76.90
	50 cm	77.43	53.23	80.17	70.28	85.37	72.90	91.00	83.09
	100 cm	82.23	58.27	86.77	75.76	97.63	81.20	99.23	92.69
	Mean (grass species)	79.18	56.40	80.61		87.51	71.94	93.22	
	Row Mean		72.06				84.23		
4 Jul-Aug 02	25 cm	63.10	44.77	73.67	60.51	74.30	62.33	71.03	69.22
	50 cm	62.97	50.30	75.80	63.02	75.43	68.83	72.77	72.34
	100 cm	74.37	51.63	75.57	67.19	88.23	71.57	85.37	81.72
	Mean (grass species)	66.81	48.90	75.01		79.32	67.58	76.39	
	Row Mean		63.57				74.43		
5 Oct-Nov 02	25 cm	65.567	34.833	65	55.13	78	52.1	65.233	65.11
	50 cm	55.667	42.167	65.833	54.56	87.333	58.767	68.1	71.40
	100 cm	65.433	42.4	66.333	58.06	115.433	62.967	80.267	86.22
	Mean (grass species)	62.22	39.80	65.72		93.59	57.94	71.20	
	Row Mean	55.91				74.24			
6 Jan-Feb 03	25 cm	68.267	38.167	71.633	59.36	62.367	53.567	88.667	68.20
	50 cm	60.433	44.833	73.1	59.46	61.1	63.433	91.6	72.04
	100 cm	57.367	43.167	81.367	60.63	81.367	66.167	93.033	80.19
	Mean (grass species)	62.02	42.06	75.37		68.28	61.06	91.10	
	Row Mean	59.81				73.48			
7 Apr-May 03	25 cm	67.7	35.5	64.433	55.88	79.333	49.633	85.567	71.51
	50 cm	66.433	40.367	68.1	58.30	80.033	59.267	86.7	75.33
	100 cm	80.5	38.5	76.433	65.14	92.9	61.6	89.567	81.36
	Mean (grass species)	71.54	38.12	69.66		84.09	56.83	87.28	
	Row Mean	59.77				76.07			
8 Jul-Aug 03	25 cm	71	39	67.433	59.14	80.333	51	88.333	73.22
	50 cm	67.333	41.667	71.9	60.30	82.667	62.333	89.7	78.23
	100 cm	85	44.667	79.667	69.78	93	65	92.567	83.52
	Mean (grass species)	74.44	41.78	73.00		85.33	59.44	90.20	
	Row Mean	63.07				78.33			
Mean (grass species) over harvests and inter-plant spacing		61.70	50.61	65.98		76.44	66.96	77.14	

Harvest x Grass species	**	5.98
Inter-row spacing x Grass species	NS	-
Harvest x Inter-row spacing x Grass species	**	8.47
Inter-plant spacing x Grass species	**	3.66
Harvest x Inter-plant spacing x Grass species	NS	-
Inter-row spacing x Inter-plant spacing x grass species	*	5.18
Harvest x Inter-row spacing x Inter-plant spacing x grass species	NS	-
CV (%)		13.77

Statistical Parameters

	F-Test	LSD (5%)
Harvest	**	3.45
Inter-row spacing	**	1.72
Harvest x Inter-row spacing	NS	-
Inter-plant spacing	**	2.11
Harvest x Inter-plant spacing	NS	-
Inter-row spacing x Inter-plant spacing	**	2.99
Harvest x Inter-row spacing x Inter-plant spacing	NS	-
Grass species	**	2.11

Effect of Maturity Stage on Seed Weight per se and Seed Quality in Indigenous Rangeland and Forage Grass Species

Saleem.Nadaf, Safaa Al-Farsi, Saleh Al-Hinai, Mohamed Al-Adawy and Rashid Al-Hinai
Ministry of Agriculture & Fisheries
Oman

Abstract

Two indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE) and Coelachyrum piercii L.(UAE) collected under ICARDA- APRP Phase- I were investigated along with Chloris gayana L., a popular perennial grass, under ICARDA- APRP Phase-II to understand effect of maturity stage on their seed weight (with husk) per se and seed quality from November 2002 at two locations namely Livestock Research Center, Rumais (LRC) in the Batinah region and Agriculture Research Station, Jimah (JRS) in the Interior region. Samples of inflorescences of grass species were collected at each of four maturity stages viz. at physiological maturity stage (PM), one week after physiological maturity (1WAPM), two weeks after physiological maturity (2WAPM) and three weeks after physiological maturity (1WAPM). The preliminary results of the ongoing investigations spanning three harvesting times up to May 2003 indicated the existence of differential expression of the seed related traits in three grass species studied at different stages of maturity in different times of harvests in both the locations. In all the grass species there was gradual and significant decrease ($p<0.05$) in seed weight/inflorescence from physiological maturity (PM) to the subsequent stages. On the contrary, there was significant increase (improvement) ($p<0.05$) in germination % from PM to 1WAPM or 2 WAPM and then decrease at 3WAPM depending upon the time of harvest. Interaction effect of harvesting time and maturity stage was highly significant ($p<0.01$) in all the grass species. At LRC and JRS, in all the three grass species studied, 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 (51 to 69 %) than that at preceding and succeeding stages. This indicated that good quality seed could be harvested at this stage but the loss of seed weight/ inflorescence at this stage from 1WAPM was found to be from 5 to > 10% and significant. 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). In May, germination % was significantly higher ($p<0.05$) at 1WAPM (52 to 60 %) than that at preceding and succeeding stages, in general, in all the grass species and declined significantly in succeeding stages. At LRC, germination % recorded at 3WAPM was 42-44 % but at JRS, it was up to 35-37 %. This indicated that in summer deterioration of seed was fast at JRS probably because of more hot (by at least 1º C) and dry weather than that at LRC characterized by hot and humid weather. Thus the present results, although preliminary, have 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.

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. Moisture content falls quite rapidly after full development of seed, which affects the overall viability of harvested seeds. 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). In light of the above, the investigations are being conducted in two locations (Livestock Research Center (LRC), Rumais in the Batinah region and Agriculture Research Station (JRS), Jimah in the Interior region) since November 2002 under ICARDA-APRP Phase –II towards knowing the effect of maturity stage on seed weight per se and seed quality and establishing optimum stage of maturity in the indigenous rangeland and forage grass species. This report discusses results of the ongoing investigations spanning three harvesting times up to May 2003.

Materials and Methods

The material under study includes two indigenous rangeland forage species viz. Buffel grass-Cenchrus ciliaris L. (UAE) and Coelachyrum piercei L. (UAE) collected under ICARDA-APRP Phase–I (Peacock et al., 2000) and Rhodes grass (Chloris gayana Kunth.)- Katambora, which are under investigation in our another experiment initiated under drips 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. 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).

Table 1. The meteorological data of Live Stock Research Center, Rumais

Year	Average of 1995 - 2001			
	Max.	Min.	R.H	Sunshine
Month	T (C^o)	T (C^o)	(%)	(hrs)
Jan.	25.2	15.7	66.3	8.6
Feb.	26.4	16.9	63.1	9.3
Mar.	28.7	19.1	63.3	9.5
Apr.	35.0	22.8	52.5	10.6
May	39.7	27.8	45.5	11.4
Jun.	39.6	28.8	55.9	11.5
Jul.	38.2	29.3	56.8	11.0
Aug.	36.7	28.3	63.8	10.7
Sep.	35.8	26.1	60.6	10.0
Oct.	34.5	23.1	58.8	9.7
Nov.	30.0	19.6	66.2	9.3
Dec.	27.7	18.3	60.5	8.9

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

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

Year	Average of 1997 - 1998			
	Max.	Min.	R.H	Sunshine
Month	T (C^o)	T (C^o)	(%)	(hrs)
Jan.	22.5	12.8	62.3	8.1
Feb.	27.3	14.8	47.9	9.0
Mar.	29.6	17.9	46.5	9.9
Apr.	34.1	20.5	38.6	10.6
May	40.0	25.0	24.2	10.6
Jun.	42.3	28.3	30.5	10.8
Jul.	42.4	28.4	33.4	10.5
Aug.	41.4	27.6	39.9	10.3
Sep.	39.5	25.2	36.5	10.2
Oct.	35.5	21.9	34.8	10.2
Nov.	30.2	17.9	42.8	8.7
Dec.	25.6	14.8	55.0	7.2

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

The present investigations were initiated from November 2002. 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 maturity stages 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). These inflorescences were dried under shade for about two weeks when they were expected to possess about 10-12% moisture %. So far, samples of inflorescences have been collected at four times of harvest respectively during November, 2002, February 2003, May 2003 and August 2003 but the results of the samples harvested three times up to May 2003 are presented in this report.

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 harvesting time, grass species and stage of maturity as factors in CRD using MSTAT-C computer program (Gomez and Gomez, 1984).

Results and Discussion

The preliminary results of the ongoing 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 stages of maturity in different times of harvests (Tables 1 to 4). 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 main factors except harvesting viz. grass species and stage of maturity and effects of their interactions except that of one 2-factor interaction viz. harvesting time x maturity stage and 3-factor interactions, 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 (250.81 mg at LRC and 252.15 mg at JRS) recorded significantly highest (p<0.05) mean inflorescence weight over harvesting times followed by Chloris gayana (208.77 mg at LRC and 210.82 mg at JRS) and Coelachyrum piercei (113.14 mg at LRC and 114.49 mg at JRS).

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

In both the locations, inflorescence weight of different harvesting times was found to be not significant either in respect of Cenchrus ciliaris (236.25 to 262.87 mg at LRC and 244.40 to 261.10 mg at JRS) or in Coelachyrum piercei (110.61 to 116.48 mg at LRC and 112.83 to 114.83 mg at JRS) and Choris gayana (191.81 to 234.49 mg at LRC and 183.90 to 244.32 mg at JRS).

In all the grass species there was gradual decrease in inflorescence weight from physiological maturity (PM) to the subsequent stages. In respect of Cenchrus ciliaris, the decrease in inflorescence weight was significant (p<0.05) from PM (277.78 mg) to 1WAPM (270.71 mg), 2WAPM (231.71 mg) and 3WAPM (223.03 mg) at LRC. However, at JRS, the decline in inflorescence weight was although gradual but not significant only between PM (278.29 mg) and 1WAPM (271.93 mg). Similarly, in case of Chloris gayana, decrease in the weight of the inflorescence was significant (p< 0.05) from first (PM, 239.19 mg at LRC; 241.96mg) to the last (3WAPM, 174.66 mg at LRC; 175.54 mg at JRS) stages of maturity in both the locations. In case of Coelachyrum piercei, however, decrease between the inflorescence weights of 1WAPM (113.72 mg at LRC and 115.28 mg at JRS) and 2WAPM (113.26 mg at LRC and 113.98 mg at JRS) was only not significant (p>0.05).

Seed weight (with husk) / inflorescence (mg)

In respect of seed weight, the effects of all the main factors viz. harvesting, grass species and stage of maturity and effects of their interactions except that of one 2-factor interaction viz. harvesting time x maturity stage and 3-factor interactions, were highly significant effect ($p<0.05$) in both the locations. (Tables 4 (a) and (b)). The grass species behaved differentially in the development of seed in the two locations. Just like in inflorescence weight, in both the locations, Cenchrus ciliaris (195.40 mg at LRC and 199.16 at JRS) recorded significantly highest ($p<0.05$) mean seed weight over harvesting times followed by Choris gayana (128.40 mg at LRC and 130.65 mg at JRS). Coelachyrum piercei recorded least seed weight (52.89 at LRC and 54.34 at JRS).

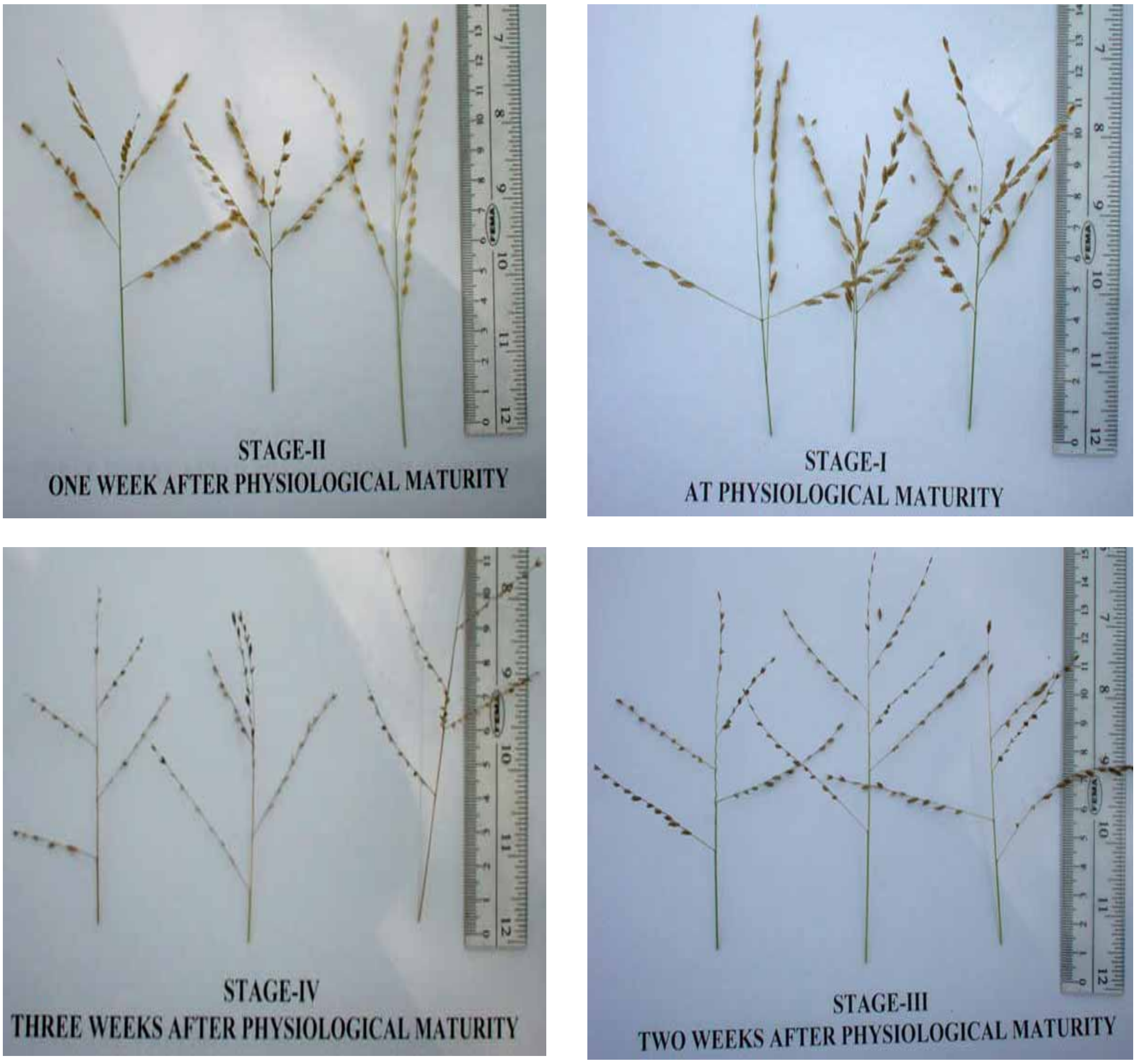


Plate 2. Different stages of maturity in Coelachyrum piercei L.

Seed weight of Cenchrus ciliaris was significantly ($p<0.05$) highest in May (207.36 mg) followed by that in November (196.20 mg) and February (182.65 mg) at LRC while it was highest significantly ($p<0.05$) in November (205.50 mg) followed by that in May (198.15 mg) and February (193.83 mg) at JRS. In respect of Coelachyrum piercei, there was no significant difference ($p>0.05$) between seed weights of any harvesting times at both the locations. In Choris gayana, seed weight of February (144.00 mg at LRC and 153.53 mg at JRS) was significantly highest ($p<0.05$) followed by that of November (124.08 mg at LRC and 125.60 mg at JRS) and May (117.12 mg at LRC and 112.83 mg at JRS). In all the grass species there was gradual decrease in seed weight/inflorescence from physiological maturity (PM) to the subsequent stages. In both LRC and JRS, the decrease in seed weight was gradual and significant ($p<0.05$) from PM to 3WAPM not only in Cenchrus ciliaris (PM-226.11 and 229.42 mg; 1WAPM-212.68 and 216.57 mg; 2WAPM-175.82 and 181.39 mg; 3WAPM-167.00 and 169.26 mg) but also in Chloris gayana ((PM- 156.21and 158.73 mg; 1WAPM-137.39 and

139.82 mg; 2WAPM-120.07 and 121.88 mg; 3WAPM-99.92 and 102.17 mg). In case of Coelachyrum piercei, however, decrease between the seed weights of 1WAPM (53.86 mg at LRC and 54.71mg at JRS) and 2WAPM (51.36 mg at LRC and 53.11mg at JRS) was only not significant ($p>0.05$).

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

Seed recovery from inflorescence (%)

In respect of seed recovery from inflorescence, only the effects of grass species and maturity stage were highly significant ($p<0.01$) at both the locations (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 (77.65% at LRC and 78.75 % at JRS) recorded significantly highest ($p<0.05$) mean seed recovery over harvesting times followed by Chloris gayana (61.16% at LRC and 61.59% at JRS) and Coelachyrum piercei (46.41% at LRC and 47.16% at JRS). Harvesting times had no significant difference ($p>0.05$) in respect of seed recovery % in both the locations. In all the grass species there was gradual and significant ($p<0.05$) decrease in the seed recovery from the stage of physiological maturity (PM) to the subsequent stages in both the locations. In case of Cenchrus ciliaris, the decrease was from 81.43 % (PM) to 74.83% (3WAPM) at LRC and from 82.43 % (PM) to 75.47 % (3WAPM) at JRS while in Chloris gayana it was from 65.30 % (PM) to 57.33 % (3WAPM) at LRC and from 65.61 % (PM) to 58.18 % (3WAPM) at JRS and in Coelachyrum piercei, the decrease was from 49.99 % (PM) to 42.94 % (3WAPM) at LRC and from 50.69 % (PM) to 43.80 % (3WAPM) at JRS. Such decrease in seed recovery in subsequent stages of maturity 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. 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 harvesting time, maturity stage and effect of their interaction were highly significant ($p<0.01$) in both the locations (Tables 6 (a) and (b)). The grass species behaved differentially with respect to germination (%) in the two locations at different times of harvest in different stages of maturity. At LRC, mean germination % Cenchrus ciliaris recorded in November (54.67 %) was on par with that in February (54.33 %). Germination % of Cenchrus ciliaris recorded in May (48.83 %) was significantly lowest ($p<0.05$) than the former two recordings. At JRS, however, germination % of Cenchrus ciliaris recorded in November (50.67 %) was significantly highest ($p<0.05$) followed by that in May (46.67 %) and February (43.92 %). In respect of Coelachyrum piercei, germination percentages recorded in November (53.92 %) and February (54.00 %) were on par with each other at LRC, which were significantly higher ($p<0.05$) than that recorded in May (48.33 %) while at JRS, germination % of Coelachyrum piercei recorded in November (50.42 %) was significantly higher ($p<0.05$) than that in February (44.42 %). Similarly, in respect of Chloris gayana germination percentages recorded in November (51.91 %) and February (53.25 %) were on par with each at LRC, which were significantly higher ($p<0.05$) than that recorded in May (47.67 %) while at JRS, germination % of Chloris gayana recorded in November (51.33 %) was significantly highest ($p<0.05$) followed by that in May (47.50 %) and February (45.67 %) but latter two were not-significant ($p>0.05$).

In respect of germination % of different maturity stages in Cenchrus ciliaris, there was gradual and significant ($p<0.05$) increase in germination % from PM (41.44 %) to 2WAPM (62.11 %) and then it dropped significantly to 53.78% at 3WAPM at LRC but in JRS, germination % was found significantly increased ($p<0.05$) from PM (42.33 %) to 2WAPM (53.00 %), which then dropped significantly at 3WAPM (42.89 %). Increase in germination % from 1WAPM to 2WAPM was however, not significant ($p>0.05$). Coelachyrum piercei had almost similar trend in germination % of different maturity stages as noticed in case of Cenchrus ciliaris in both the locations (Tables 6 (a) and (b)). In case of Chloris gayana, however, there was different behavior. In both the locations, there was significant increase ($p< 0.05$) in germination % through stages from PM (42.89 % at LRC and 42.78 % at JRS) up to 2 WAPM (60.89 % at LRC and 54.89 % at JRS) which later dropped significantly ($p<0.05$) to 49.11 % and 45.22 % at 3WAPM at LRC and JRS, respectively.

Interaction effect of harvesting time and maturity stage 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 (51 to 69 %) than that at preceding and succeeding stages in all the three grass species studied. This indicated that good quality seed could be harvested at this stage but the loss of seed weight/ inflorescence from 1WAPM was found to be from 5 to > 10% and significant (Figs. 1 to 6). 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 to 60 %) than that at preceding and succeeding stages, in general, in all the grass species and declined significantly in succeeding stages. At LRC, germination % recorded at 3WAPM was 42-44 % but at JRS, it was up to 35-37 % (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 weather (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 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, although preliminary, have 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.

Table 3(a). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at LRC, Rumais

Grass Species	Harvesting time	Inflorescence weight (mg)				
		At PM	1WAPM	2WAPM	3WAPM	**Mean**
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**
	Mean	**277.78**	**270.71**	**231.71**	**223.03**	250.81
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**
	Mean	**133.49**	**113.72**	**113.26**	**92.11**	113.14
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**
	Mean	**239.19**	**220.89**	**200.36**	**174.66**	208.77

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	NS	-
Grass species	**	5.83
Havesting time x Grass species	**	10.11
Maturity stage	**	6.74
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	11.67
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	6.62	

Table 3(b). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at JRS, Jimah

Grass Species	Harvesting time	**Inflorescence weight (mg)**				
		At PM	1WAPM	2WAPM	3WAPM	**Mean**
Cenchrus 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
	Mean	278.29	271.93	234.24	224.14	252.15
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
	Mean	135.53	115.28	113.98	93.19	114.49
Chloris gayana L.	H1 (Nov '02)	239.07	215.40	196.60	165.87	204.23
	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
	Mean	241.96	223.72	202.04	175.54	210.82

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	NS	-
Grass species	**	7.47
Havesting time x Grass species	**	12.94
Maturity stage	**	8.63
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	14.95
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	8.41	

Table 4(a). Means of seed weight) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at LRC, Rumais

Grass Species	Harvesting time	Seed weight/inflorescence (mg)				
		At PM	1WAPM	2WAPM	3WAPM	**Mean**
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**
	Mean	**169.58**	**212.68**	**175.82**	**167.00**	195.40
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**
	Mean	**66.84**	**53.86**	**51.36**	**39.50**	52.89
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**
	Mean	**156.21**	**137.39**	**120.07**	**99.92**	128.40

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	**	4.14
Grass species	**	4.14
Havesting time x Grass species	**	7.18
Maturity stage	**	4.79
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	8.29
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	7.15	

Table 4(b). Means of seed weight) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at JRS, Jimah

Grass Species	Harvesting time	Seed weight/inflorescence (mg)				
		At PM	1WAPM	2WAPM	3WAPM	**Mean**
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
	Mean	229.42	216.57	181.39	169.26	199.16
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
	Mean	68.68	54.71	53.11	40.88	54.34
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
	Mean	158.73	139.82	121.88	102.17	130.65

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	**	5.26
Grass species	**	5.26
Havesting time x Grass species	**	9.11
Maturity stage	**	6.08
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	10.53
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	8.90	

Table 5 (a). Means of seed recovery from inflorescence (%) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at LRC, Rumais

Grass Species	**Harvesting time**	**Seed Recovery from inflorescence (%)**				
		At PM	**1WAPM**	**2WAPM**	**3WAPM**	**Mean**
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**
	Mean	**81.43**	**78.51**	**75.84**	**74.83**	77.65
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**
	Mean	**49.99**	**47.37**	**45.36**	**42.94**	46.41
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**
	Mean	**65.30**	**62.14**	**59.87**	**57.33**	61.16

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	NS	-
Grass species	**	0.68
Havesting time x Grass species	NS	-
Maturity stage	**	0.79
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	NS	-
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	2.40	

Table 5 (b). Means of seed recovery from inflorescence (%) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at JRS, Jimah

Grass Species	**Harvesting time**	**Seed Recovery from inflorescence (%)**				
		At PM	**1WAPM**	**2WAPM**	**3WAPM**	**Mean**
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
	Mean	82.43	79.66	77.44	75.47	78.75
Coelachyrum piercei L.	H1 (Nov '02)	51.30	48.13	45.94	43.85	47.30
	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
	Mean	50.69	47.47	46.66	43.80	47.16
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
	Mean	65.61	62.35	60.21	58.18	61.59

Statistical Parameters

	F-Test	LSD (5%)
Harvesting time	NS	-
Grass species	**	0.66
Havesting time x Grass species	NS	-
Maturity stage	**	0.77
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	NS	-
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	2.31	

Table 6 (a). Means of germination % of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at LRC, Rumais

Grass Species	Harvesting time	Germination %				
		At PM	**1WAPM**	**2WAPM**	**3WAPM**	**Mean**
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**
	Mean	**41.44**	**53.11**	**62.11**	**53.78**	52.61
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**
	Mean	**41.89**	**53.44**	**60.55**	**52.44**	52.08
Chloris gayana L.	H1 (Nov '02)	42.67	46.33	65.33	53.33	**51.91**
	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**
	Mean	**42.89**	**50.89**	**60.89**	**49.11**	50.94

Statistical Parameters

	F-Test	**LSD (5%)**
Harvesting time	**	1.89
Grass species	NS	-
Havesting time x Grass species	NS	-
Maturity stage	**	2.19
Harvesting time x Maturity stage	**	3.79
Grass species x Maturity stage	NS	-
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	7.91	

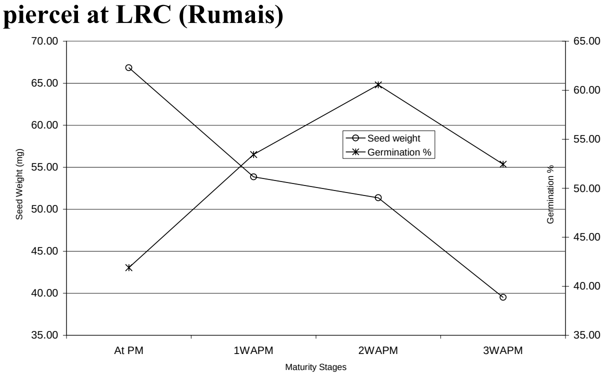
Table 6(b). Means of germination % of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and three harvesting times at JRS, Jimah

Grass Species	Harvesting time	Germination %				
		At PM	**1WAPM**	**2WAPM**	**3WAPM**	**Mean**
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
	Mean	42.33	50.11	53.00	42.89	47.08
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
	Mean	43.89	49.22	53.89	43.44	47.61
Chloris gayana L.	H1 (Nov '02)	41.67	47.67	59.67	56.33	51.33
	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
	Mean	42.78	49.78	54.89	45.22	48.17

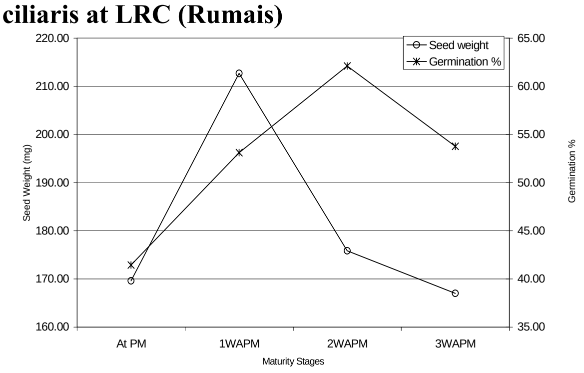
Statistical Parameters

	F-Test	**LSD (5%)**
Harvesting time	**	1.77
Grass species	NS	-
Havesting time x Grass species	NS	-
Maturity stage	**	2.04
Harvesting time x Maturity stage	**	3.53
Grass species x Maturity stage	NS	-
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	8.05	

F2. Effect of maturity stage on seed weight /inflorescence and germination % of Coelachyrum piercei at LRC (Rumais)



F3. Effect of maturity stage on seed weight/ inflorescence and germination % of Cenchrus ciliaris at LRC (Rumais)



Morphological Characterization of Two Rangeland Grass Species

Saleem K. Nadaf, Safaa M. Al-Farsi and Saleh A. Al-Hinai
Ministry of Agriculture & Fisheries
Oman

Abstract

Investigations on characterization of two perennial rangeland forage species namely Lasiurus hirsutus L.(Buraimi accession) and Panicum turgidum L. (Buraimi and Izki accessions) were undertaken during 2002-2003 by using representative samples taken at different growth stages. The Buraimi accession of Lasiurus hirsutus L was characterized in respect of as many as 19 pigmentation characters and 8 morphological traits while the two accessions (Buraimi and Izki) were characterized in respect of as many as 19 pigmentation characters and 11 morphological traits.

Introduction

Sultanate of Oman has a large area of rangelands in the Arabian Peninsula especially in Dhofar Jabal areas of South Oman apart from the ones in the North Oman. All the collected germplasm need to be classified in different categories they belong with passport information. Each species will have to be characterized for identification using most important highly heritable morphological features depending on the extent of facilities available. These features called descriptors would help in identification of true to type individuals in the plant stand of seed multiplication plots. Such descriptors would be also of use in visual assessment for reaction to abiotic and biotic stresses for identifying respective favorable genes controlling tolerance. The characterization studies were initiated during 2001-2002. The two cultivars of Cenchrus ciliaris viz. an indigenous collection and Australian variety were characterized in respect of as many as 15 pigmentation characters and 7 morphogical traits. However, Coelachyrum piercei was characterized in respect of 12 pigmentation characters and 8 morphogical traits. In continuation of these studies, two perennial rangeland forage species namely Lasiurus hirsutus L.(Buraimi accession) and Panicum turgidum L. (Buraimi and Izki accessions) were considered for characterization during 2002-2003.

Materials and Methods

Representative samples of two perennial rangeland forage species namely Lasiurus hirsutus L.(Buraimi accession) and Panicum turgidum L. (Buraimi and Izki accessions) grown in pots under shade house and in the field at Livestock Research Station, Rumais were collected at different growth stages in both winter and summer of 2002-2003. These samples were studied in the laboratory not only for nature of morphological characters but also for presence or absence of anthocyanin pigmentation on various plant parts.

Results and Discussion

The results of investigations have established distinct descriptors of two perennial rangeland forage species namely Lasiurus hirsutus L.(Buraimi accession) and Panicum turgidum L. (Buraimi and Izki accessions) in respect of morphological and pigmentaion characters (Tables 1). The Buraimi accession of Lasiurus hirsutus L was characterized in respect of as many as 19 pigmentation characters and 8 morphological traits while the two accessions (Buraimi and Izki) were characterized in respect of as many as 19 pigmentation characters and 11 morphological traits. These descriptors will be used later in identifying similar or different ecotypes that we find in our future collection missions.

Table 1. Anthocyanin pigmentation and morphological marker characters established in Lasiurus hirsutus L. (Rumais accession)

Marker Characters (Rumais accession)	*Lasiurus hirsutus*
I. Pigmentation Characters pigmentation in)	(Anthocyanin
1. Culm base	Green
2. Leaf blade	Green
3. Leaf base	Green
4. Leaf margin	Green
5. Leaf tip	Green
6. Sheath pulvinus	Purple
7. Pulvinus ring	Purple
8. Node	Purple
9. Nodal ring	Green
10. Internode	Green
11. Auricle	Colourless
12. Juctura	Colourless
13. Junctura Back	Colourless
14. Panicle puvinus	Green
15. Panicle axis	Green
16. Lemma/palea	Light purple
17. Anther colour	Yellow
18. Stigma	Hairy, colourless
19. .Seed color	Dark brown to Black
II. Morphological characters	
1. Leaf blade	Short
2. Flag leaf	Short
3. Nodal nature	Bent
4. Plant Height	Tall
5. Panicle type	Dense
6. Panicle length	Medium
7. Panicle exsertion	High
8. Shattering of seeds	More

Table 2. Anthocyanin pigmentation and morphological marker characters established in Panicum turgidum L.(Buraimi accession)

Marker Characters		*Panicum turgidum* (Buraimi accession)
I. Pigmentation Characters		(Anthocyanin pigmentation in)
1.	Culm base	Green
2.	Leaf blade	Green
3.	Leaf base	Green
4.	Leaf margin	Green
5.	Leaf tip	Green
6.	Sheath pulvinus	Green
7.	Pulvinus ring	Green
8.	Node	Green
9.	Nodal ring	Green
10.	Internode	Green
11.	Auricle	Colourless-whitish
12.	Juctura	Colourless
13.	Junctura Back	Colourless
14.	Panicle puvinus	Green
15.	Panicle axis	Green
16.	Lemma/palea	Green
17.	Anther colour	Yellow
18.	Stigma	Bifid, Hairy, coloured (Dark Orange)
19.	Seed color	Brown to Dark brown
II. Morphological characters		
1.	Leaf blade	Short
2.	Flag leaf	Very short
3.	Nodal nature	Bent
4.	Plant Height	Tall (95-110 cm)
5.	Panicle type	Lax
6.	Awns	Present
7.	Stigma	Bifid, hairy
8.	Panicle length	Long (> 12 cm)
9.	Panicle exsertion	High
10.	Shattering of seeds	More
11.	Seed size	Medium to large

Table 3. Anthocyanin pigmentation and morphological marker characters established in Panicum turgidum L. (Izki accession)

Marker Characters		***Panicum turgidum*** (Izki accession)
I. Pigmentation Characters		(Anthocyanin pigmentation in)
1.	Culm base	Green
2.	Leaf blade	Green
3.	Leaf base	Green
4.	Leaf margin	Green
5.	Leaf tip	Green
6.	Sheath pulvinus	Green
7.	Pulvinus ring	Green
8.	Node	Green
9.	Nodal ring	Green
10.	Internode	Green
11.	Auricle	Colourless-whitish
12.	Juctura	Colourless
13.	Junctura Back	Colourless
14.	Panicle puvinus	Green
15.	Panicle axis	Green
16.	Lemma/palea	Green
17.	Anther colour	Yellow
18.	Stigma	Bifid, Hairy, coloured (Dark Orange)
19.	Seed color	Dark brown to black
II. Morphological characters		
1.	Leaf blade	Short
2.	Flag leaf	Very short
3.	Nodal nature	Bent
4.	Plant Height	Tall (95-110 cm)
5.	Panicle type	Lax
6.	Awns	Present
7.	Stigma	Bifid, hairy
8.	Panicle length	Long (> 12 cm)
9.	Panicle exsertion	High
10.	Shattering of seeds	More
11.	Seed size	Small to medium

Effect of Time of Plantings and Set up Of Green Houses on the Incidence of Certain Major Pests of Cucumber

Syed Razvi, Najma Al-Zadjali, Rashid Al-Shidi; And Yousuf Al-Raeesi
Ministry of agriculture and Fisheries
Oman

Abstract

A comparison of the mean infestation levels of the leaf miner on cucumber in three set up of green houses at different planting timings indicate that the mean infestation is high (8.94 infested leaves / block) in February planting. The infestation was low (3.65 infested leaves / block) in September planting and least (0.06 infested leaves / block) in June planting. It was also low (0.32 infested leaves / block) in November planting in GH with non-cooling system. A comparison of the levels of infestation of leaf miner between the blocks of the crop indicate that it was high in block-C when compared to block-A and block-B of all the plantings in cooling GH, though the difference was significant only in February planting. On the other hand in non-cooling green house the infestation was relatively high in block–A (6.14 infested leaves / block) when compared to block-B (4.78 infested leaves / block) and block-C (4.70 infested leaves / block). However, the difference was not significant.

The mean whitefly infestation was very high (17.1 whitefly adults /leaf) in September planting of GH # I, followed 2.39 whitefly adults /leaf in June planting. However, it was low (0.02) in February planting and also in the November planting (0.05) of non-cooling green house. A comparison of the infestation between the blocks of GH # I, September planting, indicate that the infestation was high in block- A, medium in block- B and low in block- C, being 26.36, 15.23 and 9.88 adults / leaf, respectively. The infestation was low in the green house with non-cooling system. However, the trend remains the same. The possible reason for high populations in blocks A & B is the high temperatures in these blocks. The temperatures being 34.5 and 33.5 o C, respectively as compared to 32.2 o C in block C.

It is interesting that there was no aphid infestation in September and June plantings of GH # I. However, high infestation (0.2) was recorded in February planting of GH # III and in November planting of GH # IV. It was relatively high in block-C when compared to blocks-B and A, though the difference was not significant. Thrip is a sporadic pest and was seen only in the September planting in GH # I. It was found to be 12.61 adults / yellow sticky trap. It was high in block-A, followed by block-B. The difference was not significant.

Mite infestation was expressed as the number of alive mites / leaf circle of 2 cm diameter. It was very high (8.53 mites) in the September planting followed by February planting (3.12 mites). It was very low (0.01 mites) in June planting. The infestation in the non-cooling green house was also low (0.86 mites). There was no significant difference between the blocks with regard to mite infestation.

The yield of cucumber in terms of number of fruits and weight was very high in GH # IV (non- – cooling green house with black mulch, soil culture), being19094 fruits weighing 2314.9 Kg, followed by GH # III (cooling system with black polythene mulch, soil culture) with 11412 fruits weighing 1601 Kg. It was low (6011 fruits weighing 686.30 Kg) in GH-I, June planting. The lowest yield recorded was in GH # I, September planting being 2666 fruits weighing 268.01 Kg.

Introduction

In Oman, cucumber is largely grown in green houses throughout the year. This crop is attacked in green house mainly by leaf miner, Liriomyza trifolii (Agromyzidae Diptera), aphid, Aphis gossypi (Aphididae ; Homoptera), whitefly, Bemsia tabaci (Aleurodidae Homoptera), thrips, Thrips tabaci (Thripidae Thysonoptera) and mite, Tetranychus sp (Tetranichidae Acharina).

It is the general observation that the incidence of the pests is not the same through out the year. Further it is more in certain portions of the green house while it is less in other parts. Attempts were made to know as which part of the year the pest incidence is high and also whether there is any significant difference in the pest incidence between the different portions of the green house, and if so what could be the possible reason. Practically little work has been done in Oman on the green house cucumber.

It is therefore, felt necessary to conduct some experiments to gather information so as to compare the incidence of major insect pests of cucumber in different dates of plantings and also in different portion of the green houses, which will be helpful in developing a rational suitable management strategy to solve pest problems.

Materials and Methods

The experiment was conducted at Agriculture Research Center, Rumais, during the year 2002-2003 in three green houses, namely green house (GH) # I, GH # III and GH # IV. Green house # I and III are having evaporative cooling system while in GH # IV there is no cooling system (only ventilation). In GH I, two crops were taken as transplanted soil less culture crop. The first planting was done in September 02 and second planting was done in June 03. While in each of GH III & IV only direct sowings were done as soil culture with black polythene mulch in February-03 and November- 02, respectively. Seeds of cucumber (cultivar Hanna F1) were sown as nursery in jiffy-7 pots, under agryl cover to fully protect them against insects and mites. The seedlings were transplanted in the respective green houses in five rows each consisting of 146 plants with a total of 730 plants in each green house. The space between the rows was 1.5 m and between plants was 50 cm. Irrigation was given daily for 10 to 15 minutes by double pipe lines drip system. The crop in each green house was divided into three equal parts width wise and named as blocks as A, B and C. Block-A is the front portion just after the entrance, block-B is the middle portion and block-C is the hind portion.

The plants were under observations from the beginning of the experiment for the attack of any insect or mite. When any leaf with symptoms of leaf miner infestation was seen it was recorded, plucked and thrown out. For whitefly 10 leaves / block were observed carefully by looking on the under surface of the leaves and the number of adult whiteflies sitting on the leaf were counted. With regard to the aphid infestation all the plants of each block were observed and a grade on a scale of 0 to 5 is given to each plant based on the damage symptoms. The grades were 0 = Healthy, 1 = infestation low (1-2 leaves became pale), 2 = infestation moderate (3-4 terminal leaves became pale), 3 = infestation high (5-6 terminal leaves became pale and curled), 4 = infestation severe (most of the terminal leaves become pale and curled) and 5 = plant completely killed.

Thrip population was monitored by using YSTs. In each block one YST of size 30x7 cm was hanged in such a way that it reaches close to the upper canopy of the crop.

For mite infestation five young leaves were plucked from each block and taken to laboratory to count the number of alive mite (nymphs and adult) on leaf circle of diameter 2 cm.

Temperatures were recorded for each block of the green houses. Harvesting was done twice a week and the number of fruits and weight of all pickings was recorded. The data were subjected to statistical analysis.

A package of control practice was adopted on need base for each pest. For controlling leaf miner regular plucking of infested leaves was done. For mass trapping of whitefly YSTs were used (mechanical methods). At higher population insecticide soap (Savona) was sprayed @ 10 ml / liter water. Tobacco decoction (prepared by sipping shade-dry tobacco leaves @ 100 g leaves / liter water for 48 hours, filtered and the stock solution was diluted with water in the ratio of 15 and liquid soap was added as wetting agent before spraying against aphid. Sulphur 80 WP @ 20 g / 10 liter water was sprayed against mite.

Results and Discussion

Leaf miner Usually the seedlings and young plants are more susceptible to insects, same is the case with leaf miner. Since thinning of leaves is a part of the cultural practice, therefore, leaf miner infested leaves were regularly counted and plucked up to the age of 50 DAT. Plucking of infested leaves had started reducing the infestation. As the plants were growing, more number of new leaves were coming on the plants, but the total number of infested leaves start getting reduced. By this time the crop was in its last phase and so the plucking was stopped and as a result of this there was an increase in the infestation, but it has no bearing on the yield as the crop was in its last phase and only few pickings of fruits were left.

A comparison of the mean infestation level of the different planting timings indicate that the infestation was high (8.94 infested leaves) in February planting. It was low (3.65) in September planting and least (0.06) in June planting. The infestation was low (0.32) in November planting in GH with non-cooling system (Table 1).

The level of leaf miner infestation between the three blocks indicate that in February planting it was significantly high (15.08 infested leaves) in block-C when compared to block-B (4.74 infested leaves) and block-A (2.80 infested leaves) of GH # III, February planting. Similar was the trend of the June and February plantings of the green house I. Though the difference was not significant. On the other hand the infestation was relatively high in block–A (6.14 infested leaves / block) of GH# IV when compared to block-B (4.78 infested leaves / block) and block-C (4.70 infested leaves / block). However, the difference is not significant (Table 6).

Whitefly The mean whitefly infestation in GH # I, was very high (17.1 whitefly adults /leaf) in September planting but was relatively low (2.39 whitefly adults /leaf) in June planting. It was almost negligible in February planting of GH # III and in November plantings of non-cooling green house (GH # IV). The mean adult count was 0.02 to 0.05 whitefly adults /leaf (Table 2). With the first sign of whitefly infestation YSTs were installed in the GHs. The populations in GH # III and IV remained fluctuating at lower levels through out the crop growth, ranging from 0.01 to 0.03 adult whitefly / leaf in GH # III and 0.01 to 0.15 whitefly / leaf in GH- IV. A comparison of the mean population of the whitefly in the green houses is depicted in Fig. 1 (b). Use of YSTs as mechanical method of control was effective in controlling whitefly at lower population level. However, at higher population spraying of insecticide soap (Savona) has effectively controlled the whitefly population.

It is evident from Table 6, that the population of whitefly in September planting was significantly high in block-A (26.36 adults / leaf) over block-B (15.23 adults / leaf) and block-C (9.88 adults / leaf). The possible reason for high population in blocks A and B was the high temperatures in this block. The temperatures being 34.5 and 33.5 o C, respectively as compared to 32.1 oC in block-C. The infestation was low in the green house with non-cooling system. However, there was no significant difference between the blocks . The infestation was low also low in June planting and very low in February planting.

Aphid infestation It is interesting to note that there was no infestation of aphid in September and June plantings in GH # I. It was high in, February planting GH # III and also in GH # IV with no cooling system in the November planted crop. The average infestation grade was 0.2 / plant. The infestation in GH # IV was very low in the beginning, suddenly increased in the month of February. The population exploded within three weeks as average infestation grade reached from 0.02 to 0.11. (Table 3, Fig. 1c). The possible reason for fast building up of the aphid infestation in green house with out cooling system is that the low minimum temperatures prevailing in this green house are more congenial for the population build up. It is also the general observation that aphid population in the open fields builds up very fast during January – February. The aphid infestation is high in block-C, followed by block-B. The average infestation grades in block-C of GH # IV was 0.29, followed by block-B (0.19) and block-C (0.13). However, the difference is not significant (Table 6).

Thrip This is a sporadic pest and it was seen only in the year 2002 in September planting in the GH # I, with cooling system. It was found to be 12.61 adults / YST (Table 4, Fig. 1d).

Mite Mite is a regular pest, seen in all the plantings of the three green houses. It is expressed as the number of alive mites / leaf circle of 2 cm diameter It was very high (8.53 mites) in the GH # I, September planting, followed by February planting (3.12 mites). It was very low (0.01) in June planting. The average infestation in the non-cooling green house was 0.86 mites. It was low in the beginning but there was slight increase in the late stage of the crop (Table 5, Fig. 1e). This shows that the mite infestation was about 10 times high in September planting in GH # I and 2 – 4 times in February planting GH # III with cooling system when compared to November planting in GH # IV (non-cooling system). There is no difference between the blocks with regard to mite infestation Table 6). Spraying Sulphur 80WP @ 20 g / 10 liter water has effectively controlled mite.

Yield

The total yield of all the pickings in terms of number of fruits and weight were recorded (Table 6). The yield was highest (19094 fruits weighing 2314.9 Kg) in GH # IV, followed by GH # III (11412 fruits weighing 1601 Kg). The yield was low (2666 fruits weighing 268.01 Kg) in September planting and 6011 fruits weighing 686.30 Kg in June planting. It is evident that both the total number of fruits and their weight were very high in green house with soil culture and black polythene mulch when compared to green house with soil less culture. Further it is high in November planting in green house with out cooling system.

The data envisage that the yield between the blocks was related to the level of infestation of mite, aphid or whitefly. The low yield in block- A of GH- I, September planting may be attributed to high infestation of mite and whitefly. Similarly the low yield in block C in GH-III, February planting is attributed to high aphid infestation (Table 6).

Table 1. Infestation levels of leaf miner (Liriomyza trifolii) on cucumber at different days after plantation grown under green house condition.

GH #	Planting #	Av. No. of LM Infested leaves / block at days after plantation in the green houses									Pooled mean	LSD .05
		10	15	20	25	30	35	40	45	50		
I	I	No infestation				0.08	0.42	14.6	4.08	4.67	3.65	5.75*
	II	0.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	NS
III	I	-	8.0	2.2	0.4	3.8	8.8	29.2	-	10.2	8.94	NS
IV	I	-	1.0	0.0	-	0.0	0.6	0.0	-	-	0.32	NS

NS = Not significant; * Singificant at 0.05;
DS = Date of sowing; DP = Date of planting, GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03
GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

Table 2 . Infestation levels of whitefly (Bemisia tabaci) on cucumber at different days after plantation grown under green house condition.

GH #	Planting #	AV. No. of whitefly adults per leaf at days after plantation in different plantings of green houses																Pooled mean	LSD 0.05
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80		
I	I	-	0.47	0.62	0.98	-	3.31	1.93	-	1.66	25.4	-	27.0	38.8	-	53.9	33.6	17.1	19.65*
	II	0.05	-	0.05	0.07	0.64	-	0.33	2.69	2.58	4.31	4.85	8.36	-	-	-	-	2.36	0.74*
III	I	0.0	0.0	0.0	0.0	0.0	0.05	0.01	0.03	-	0.01	0.01	0.02	-	-	-	-	0.02	NS
IV	I	-	-	-	-	0.05	0.09	-	0.02	0.03	-	0.05	0.03	0.01	-	0.15	0.01	0.05	NS

NS = Not significant; * Singificant at 0.05;
DS = Date of sowing; DP = Date of planting, GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03
GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

Table 3. Infestation levels of aphid (Aphis gossypii) on cucumber at different days after plantation grown under green house condition.

GH #	Planting #	Av. Infestation level (grade 0-5 scale) at days after plantation in different set up of green houses																Pooled mean	LSD .05
		25	30	35	40	45	50	55	60	65	70	75	80	90	100	105	110		
I	I	NO INFESTATION																-	-
	II	NO INFESTATION																-	-
III	I	-	0.16	0.08	0.01	-	0.23	0.13	-	-	-	0.59	-					0.20	0.03*
IV	I						0.02	0.08	0.07	0.11	-	-	-	0.11	0.09	0.40	0.8	0.21	0.74*

NS = Not significant; * Singificant at 0.05
DS = Date of sowing; DP = Date of planting
GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03
GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

Table 4. Infestation levels of Thrips (Thrips tabaci) on cucumber at different days after plantation grown under green house conditions.

GH #	Planting #	Av. No. of adult thrips count per YST at days after plantation in the different plantings of green houses															Pooled mean	LSD 0.05
		10	15	20	25	30	35	40	45	50	55	60	65	70	75	80		
I	I	-	-	-	-	5.83	3.25	-	5.83	17.8	-	10.2	20.3	-	-	25.1	12.61	NS
	II	NO INFESTATION															-	-
III	I	NO INFESTATION															-	-
IV	I	NO INFESTATION															-	-

NS = Not significant;
DS = Date of sowing; DP = Date of planting
GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03
GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

Table 5 . Infestation levels of mite (Tetranychus sp) on cucumber at different days after plantation grown under green house condition.

GH #	Planting #	Av. No. of alive mite counts / leaf + at DAT in different set up of green houses														Pooled mean	LSD .05
		20	25	30	35	40	45	50	55	60	65	70	75	80	90		
I	I	-	-	0.03	0.12	34.6	2.32	2.9	5.10	6.5	7.3	15.6	-	10.8	-	8.53	7.79*
	II	0.0	0.03	0.0	0.0	0.0	-	-	-	-	-	-	-	-	-	0.01	NS
III	I	-	-	-	-	0.0	-	7.4	0.0	0.63	-	-	4.45	-	-	3.12	NS
IV	I	-	-	-	1.96	0.0	0.08	0.01	-	0.0	0.0	-	1.36	-	3.44	0.86	NS

+ Leaf = circle of 2 cm diameter on leaf , DAT = Days after transplantation
NS = Not significant; * Singificant at 0.05
DS = Date of sowing; DP = Date of planting
GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03

GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

Table-6. Infestation of certain major pests on cucumber crop grown under green house conditions and their impact on yield

GH #	Planting #	Block #	Mean infestation level of the pests during crop period					Fruit yield	
			Leaf miner	White fly	Thrip	Aphid	Mite	No.	Weight (Kg)
I	**I**	**A**	2.29	26.36	18.5	No infes tation	11.09	810	79.98
		B	2.61	15.23	13.79		7.77	897	91.05
		C	6.10	9.88	5.54		6.67	959	96.98
LSD 0.05			**NS**	**8.03***	**NS**	**----**	**NS**	**NS**	**NS**
	II	**A**	0.40	1.44	No infes tation	No infes tation	No infes tation	1974	218.0
		B	0.20	2.75				1839	201.8
		C	1.00	2.35				2198	266.5
LSD 0.05			**NS**	**0.80**	---	---	---	**NS**	**NS**
III	**I**	**A**	2.8	0.02	No infes tation	0.12	0.18	3972	584.1
		B	4.74	0.04		0.19	5.30	3907	521.2
		C	15.08	0.46		0.30	2.02	3533	495.5
LSD 0.05			**3.94***	**0.33***	----	**NS**	**NS**	**NS**	**NS**
IV	**I**	**A**	6.14	0.78	No infes tation	0.13	0.01	6256	762.5
		B	4.78	0.38		0.19	1.23	5856	708.3
		C	4.70	0.34		0.29	1.34	6982	844.1
LSD 0.05			**NS**	**NS**	----	**NS**	**NS**	**154.07***	**21.298***

Leaf miner = No. of infested leaves per block, Whitefly = No. of adult count per leaf
Thrip = No. of adult count per yellow sticky trap of size 30 x 7 cm., Aphid = grade per plant
Mite = alive mite count on circle of diameter 2 cm taken on the leaf.
NS = Not significant; * Singificant at 0.05
DS = Date of sowing; DP = Date of planting
GH = Green house
GH-I (cooling system, soil less culture) Planting I = DS = 18-9-02 DP = 29-9-02;; Planting - II = DS = 3-6-03 DP = 22-6-03
GH –III (cooling system, soil culture, black polythene mulch) Planting I = DS = 2-2-03 DP = Direct sowing
GH – IV (Non-cooling system, soil culture, black polythene mulch) Planting I = DS = 19-11-02; DP = Direct sowing

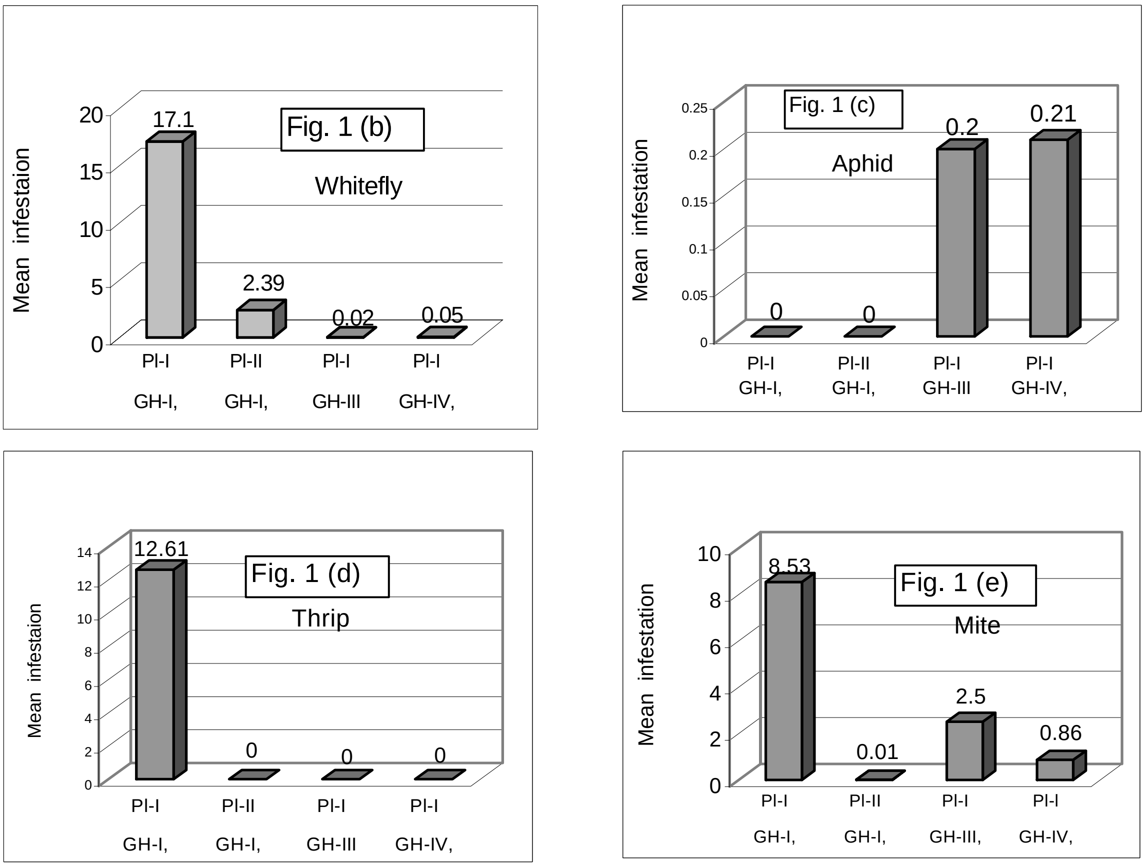


Figure-1. Effect of time of plantingsPl-I, GH-I (Sept.), Pl-II, GH-I (June), Pl-I, GH-III (Feb.), and Pl-I,GH-IV (Nov.) on the incidence of certain major pests of cucumber in green houses

Relationship between Whitefly Catches On Yellow Sticky Traps and the Actual Adult Whitefly Population on Cucumber Leaves under Cooled GH

Syed Ali Razvi, Najma Mahmood Al-Zadjali, Rashid Al-Shidi and Yousuf, M. Al-Raeesi
Ministry of agriculture and fisheries,
Oman

Abstract

Whitefly adult population counts were weekly recorded for 11 weeks in cucumber crop grown in green house during September - December 2002. The population of whitefly was also monitored every week by using yellow sticky traps (YSTs). The pooled data of the 11 consecutive weeks were subjected to correlation and regression analysis. The correlation was found to be highly significant (r = 0.640**). The simple regression equation was Y = 129.134 + 0.647X, where X is the YST catches. Since YSTs are easy to handle, they can be used to get the estimated population and based on this necessary plant protection measures can be taken.

Introduction

Whitefly (Bemisia tabaci) is one of the major insect pests of cucumber causing considerable damage to the crop. Both the nymphs and the adults suck the sap and produces honeydew, which acts as a suitable media for the sooty mould fungus to grow. Before taking any decision for chemical control measures against whitefly, it is necessary to know the level of pest population. Whitefly adult population count is not only very tedious but also time consuming. Further whitefly is a tiny insect and its adults usually fly away with any disturbance. Whiteflies are known to be attracted by yellow color. Taking the advantage of this behavior, yellow sticky traps (YSTs) are used to monitor the adult whitefly population. It is felt necessary to develop a relationship between whitefly catches YSTs and the actual adult whitefly population on cucumber leaves. This information will save time and labor in taking observations.

Materials and Methods

Cucumber crop (cultivar – Henna F1) was grown in green house with cooling system during September - December 2002 in four rows each of 25m length. The spacing between rows was 1.5 m and between plants is 50 cm. Each row was divided into three equal blocks as A, B and C. Every week in each block one small yellow sticky trap of size (30 x 7 cm) was hanged and after 48 hours the number of adult whiteflies trapped on each YST were recorded. On the same day in each block ten leaves were observed at random for actual adult whitefly count. Care was taken not to disturb the adult whiteflies sitting on the leaves. The total number of adult whiteflies on ten leaves of each block was correlated with the catches on YST of the same block. The data were subjected to correlation and simple regression analysis.

Results and Discussion

The pooled data of 11 consecutive weeks (n = 130) when subjected to simple correlation and regression analysis revealed that the correlation was highly significant (r = 0.640**). The simple regression equation was Y = 129.134 + 0.647X, where X is the YST catches and Y is the estimated adult population (Table 8, Figure 2). Since YSTs are easy to handle, they can be used as to get the estimated population. Based on the YSTs data, necessary plant protection measures can be taken.

Table.7-. Relationship between whitefly catches on yellow sticky traps and the actual adult whitefly count on cucumber under green house conditions with cooling system (GH-I, October - December 2002).

S. No.	Observation At DAT*	Av. Adult WF count per 10 leaves	Av. WF catches / YST of size 30x7 cm	Correlation"r"	Regression equation
1	15	6.2	6.60	0.604*	Y = 3.015 + 0.467 X
2	20	9.8	9.33	0.622*	Y = 4.886 + 0.521 X
3	30	33.1	23.67	0.435 NS	---
4	35	19.3	21.92	0.239 NS	---
5	45	16.6	24.50	0.893**	Y = -1.038 + 0.726 X
6	50	255.4	106.33	0.788**	Y = 158.001 + 0.899 X
7	60	193.3	279.17	0.547 NS	---
8	65	271.0	388.00	0.892**	Y = 179.616 + 0.647 X
9	80	336.3	447.75	0.137 NS	---
10	85	906.4	795.30	0.427 NS	---
11	95	727.1	429.35	0.231 NS	---
Pooled average		252.2	230.17	0.640**	Y = 129.13 + 0.647X

Correlation between YST catches of WF and adult WF count / 10 leaves
X = No. of whiteflycaught / YST, Y = No. of whitefly count / 10 leaves, where X is not equal to zeroDAT = days after transplantation, WF = whitefly, YST =yellow sticky trap NS = not significant, * Significant at 5% level, ** Significant at 1% level

Efficiency of Certain Bio-Rational Pesticides for the Control of Aphid on Cucumber Grown In Soil with Polythenemulch in GH with Non-Cooling System

Syed Ali Razvi, Najma Mahmood Al-Zadjali, Rashid Al-Shidi and Yousuf M.Al-Raeesi
Ministry of Agriculture and Fisheries
Oman

Introduction

For cucumber grown in green house pests such as aphid, whitefly and mite are constant threat. Among these the most predominant is the aphid (Aphis gossipy). Unless a sound approach is followed in handling aphid problem, it can rapidly destroy a crop. Use of conventional insecticides has invited many problems such as pest resurgence, secondary pest out break, pesticides residues etc. It is therefore, felt necessary to find eco- friendly pesticides to control pests of cucumber in green house. Keeping this in view experiment was conducted in green house during February 2003 to test certain eco- friendly pesticides viz., tobacco decoction, neem products Neemosan and Neem plus, garlic extract, turmeric extract, insecticide soap (Savona), Verticillium lacanii and Sulphur 80WP against aphid.

Materials and Methods

Cucumber crop (cultivar = Henna F1) was grown in green house with non-cooling system. The area of the green house is 360 square meters (40x9 m). The crop was grown in five rows each of length 35 m. Each row was divided in to three blocks. The spacings between the rows and plants were 1.5 m and 50 cm respectively. The sowing was done on 19-11-02 (direct sowing). The crop was attacked by aphid during February 2003 at that time certain materials were tested for their eco- friendly pesticide properties. The materials evaluated were tobacco decoction (1 Kg tobacco leaves soaked in 20 liters of water for 24 hours, filtered through fine mesh, diluted with water in the ratio of 12 and liquid soap added @ 8 drops / liter as emulsifying agent), neem products Neemosan and Neem plus each @ 10 ml / liter water, garlic extract (1 Kg garlic extract in 4 liter water + liquid soap as emulsifying agent), turmeric extract (5 gm / lit water + liquid soap as emulsifying agent), insecticide soap (Savona) 20 ml / lit water, Verticillium lacanii 100 gm in 4 lit water and Sulphur 80WP @ 2 gm / lit water against aphid. An untreated control treatment was also included where in water emulsified with liquid soap was used. Ten aphid-infested plants were selected for each treatment. The plants were sprayed with the respective materials using high volume air compressor sprayer. Care was taken to thoroughly spray the under surface of the leaves. The experiment was done in two tests. In the first test (Test I) spraying was done on 18-2-03 and observation was taken on 22-2-03 at four days after treatment. For this ten infested leaves, one from each sprayed plant for each treatment was plucked and taken to laboratory for actual counts of dead and alive aphids. Since many of the leaves were largely covered with aphids. A portion of each leaf was marked by a ring (4 cm diameter) and all the dead and alive aphids present in the circle were recorded. Aphids which were in moribund state were taken as dead. The average number of dead and alive aphid for each treatment was calculated and percentage kill was worked out. The experiment was repeated with another set of plants (Test II) with spraying on 22-2-03 and observation on 1-3-03.

Results and Discussion

The results of the two tests and their mean are presented in Table 8. The average of the two tests indicated that tobacco decoction was very effective with 86.12 % kill, followed by Savona (71.52 % kill), Neemosan (64.18 % kill) and Verticillium lacanii (54.19 % kill). Garlic and Neem plus were relatively less effective with 35 to 54 % kill. Turmeric and Sulphur 80 WP were least effective. The experiment will be repeated with more new products against aphid and also against whitefly. It is very important that the spraying should be done thoroughly on the under surface of the leaves.

Table 8. Efficacy of certain eco-friendly materials against aphids Aphis gossypii on cucumber in GH

S. No.	Treatment	Dosage g or ml / lit water	% kill in		Average % kill
			Test I	Test II	
1	Control	-----	0.0 (0.0)	0.0 (0.0)	0.0 (0.0) f
2	Tobacco extract	50	77.10 (61.41)	95.13 (77.21)	86.12 (69.31) a
3	Garlic extract	250	10.43 (18.81)	60.95 (51.35)	35.69 (35.08) d
4	Neemosan	10	59.57 (50.53)	68.78 (56.04)	64.18 (53.29) abc
5	Neemplus	10	35.12 (36.33)	66.69 (54.76)	50.91 (45.55) bc
6	*Verticillium lecanii*	25	37.01 (37.47)	71.36 (57.67)	54.19 (47.57) bcd
7	Sulphur 80WP	2	0.38 (3.53)	0.38 (3.53)	0.38 (3.53) e
8	Termeric extract	4	5.33 (13.31)	14.15 (22.14)	9.74 (17.73) e
9	Insecticide soap (Savona)	20	62.52 (52.24)	80.52 (63.79)	71.52 (58.02) ab

Figures in the parentheses are the angular transformed values
Figures followed by dissimilar letters are significantly different

Evaluation of Certain Tomato Cultivars Grown In Green House under Hydroponic System Against Pests and Diseases

Syed Ali Razvi, Najma Mahmood Al-Zadjali, Rashid Al-Shidi, Yousuf Mohammed Al-Raeesi, Ibtihal Juma Al-Raeesi and Ahmed Mohammed Al-Mantheri.
Ministry Of Agriculture and Fisheries
Oman

Abstract

Four tomato cultivars namely Niz 63-308 F1, Ammarida F1, Red Pear and Sun Cherry were grown, in a cooling green house under hydroponic system in a replicated trial during November 2002 to March 2003. The crop was attacked mainly by whitefly (Bemisia tabaci) which has transmitted a virus disease called tomato yellow leaf curl virus (TYLCV). The other pest was leaf miner (Liriomyza trifolii). The crop was free from the attack of aphid, thrip and mite. Maximum yield (94.9 Kg) was recorded in Ammarida followed by Niz 63-308 F1(87.7 Kg) and Sun Cherry (72.55 Kg). Significantly low yield (33.15 Kg) was recorded in Pear Red.

Introduction

For tomato crop, which is grown through out the year under green house conditions in Oman, pests are constant threats and high relative humidity developing inside the green house favors developing diseases. Among the pests attacking tomato in green house, the most predominant is the whitefly (Bemisia tabaci) which is also a vector of disease called tomato yellow leaf curl virus (TYLCV). This insect has developed resistance to a large number of insecticides. Further few whiteflies are sufficient to transmit the disease. Under such conditions it is very important to evaluate tomato cultivars which could show resistance to TYLCV. Keeping this in view four cultivars are evaluated under green house conditions against major pests and diseases with special reference to whitefly and the disease, TYLCV.

Materials and Methods

Four tomato (Lycopersicon esculentum) cultivars namely Niz- 63-308 F1, Ammarida F1, Red Pear and Sun Cherry were sown on 19-10-02 in fuji pots. The seedlings were fully protected under agril cover. On 17-11-02 the seedlings were transplanted in green house and grown under hydroponic system in a complete randomized design, replicated four times. There were four rows and each row was divided in to four blocks. In each block there were 30 plants. Yellow sticky traps (YSTs) were installed in the green house at the rate of three YSTs / block. A total of 48 YSTs were installed. The plants were observed during November 2002 to March 2003 for any pest and disease. Whitefly adult counts were recorded by observing 10 leaves at random in each block. In the present study attempts were made to calculate the per cent fruit set up. For this certain selected plants were observed for the disease and the plants were categorized under score as S0, S1, S2, S3 and S4, where S0 = no disease symptom (0 % infection), S1 = low disease symptom (1-10 % infection),, S2 = moderate disease symptom (11-20 % infection),, S3 = severe disease symptom (21-50 % infection),and S4 = highly severe disease symptom (51-100 % infection). The number of flowers on the plants were counted and counted and observed for the fruit set up. Based on this the per cent fruit set up in each cultivar was calculated.

Leaf miner counts were recorded by observing all the plants in each block and the number of leaf miner infested leaves were recorded. The infested leaves were plucked. The pickings of fruits were done at regular interval and the total yield was calculated. The data were subjected to statistical analysis.

Results and Discussion

The crop was attacked mainly by whitefly (Bemisia tabaci) which is also a vector of TYLCV. The incidence of whitefly was seen from the early age of the plants. The whitefly count at 15 DAT was 0.34 adults / leaf. Immediately YSTs were installed in the green house. The whitefly population was fluctuating at lower levels, ranging from 0.14 to 0.36 adult whitefly per leaf during the entire crop period. This indicate that the YSTs were effective in controlling the whitefly population (Table 9). Inspite of whitefly population the TYLCV came.

The incidence of whitefly was 0.24 adult per leaf in case of Pear Red and Sun Cherry and 0.28 adult per leaf in case of Niz-63-308F1. It was relatively high (3.65 adult / leaf) in case of Ammarida. This indicate that Ammarida is more preferred by whitefly. However, it is interesting to see that the per cent fruit set up was highest (83.9 %) in the diseased plant in this cultivar which shows that the cultivar is tolerant to TYLCV. However, there was no significant difference between the cultivars with regard to the incidence of whitefly, but significant difference is seen among the cultivar with regard to TYLCV (Table 10).

The other pest was leaf miner (Liriomyza trifolii) which was seen from the beginning of the crop. It was 14.5 infested leaves / block at 10 DAT. Thinning of infested leaves has reduced the number of infested leaves to 6.56 infested leaves / block at 15 DAT. It was 2.63, 0.19 and 3.63 infested leaves / block at 20, 30 and 35 DAT, respectively (Table 9). At a later stage of the crop the plucking of the leaves was stopped as a result the number of infested leaves increased and reached to 21.25 and 32.75 infested leaves / block at 40 DAT and 50 DAT, respectively. The infestation of the leaf miner in general is less and as such do not have any effect on the yield of the crop. The leaf miner incidence was around 30 infested leaves per block in each of Niz-63-308F1, Ammarida and Pear Red. It was relatively high (51 infested leaves per block) in the cultivar Sun Cherry (Table 9). However, there was no significant difference between the cultivars with regard to the incidence of leaf miner. The crop was free from the attack of aphid, thrip and mite.

TYLCV

The per cent fruit set up was highest (83.9 %) in the cultivar Ammarida, followed by Sun Cherry (78.57 %) and Niz-63-308 F1 (75.58 %). It was least in Pear Red (32.92 %). The significantly low fruit set up in Pear Red has reflected the yield (Table 10).

Yield

The total yield of all the pickings in each of the cultivars in terms of number of fruits and weight (Kg) were recorded. The total number of fruits harvested was maximum in Sun Cherry (5176), followed by Pear Red (1858), Niz-63-308F1(1066) and Ammarida (1024). Sun Cherry has recorded significantly higher number of fruits. The total fruit yield was highest (94.9 Kg) in Ammarida, followed by Niz-63-308F1 (87.7 Kg) and Sun Cherry (72.55 Kg). The yield was significantly low (331.5 Kg) in Pear red (Table 10).

Table-9. Infestation of certain major pests of tomato grown under hydroponic system at different days after transplantation in green house with cooling system during 2002.

S. No.	Pest	Infestation of the particular pest at days after transplantation															Pooled mean	LSD 0.05
		10	15	20	25	30	35	40	45	50	60	65	70	80	95	100		
1	LM - No. of infested leaves per block	14.5 ab	6.56 a	2.63 a	2.0 a	0.19 a	3.63 a	21.3 b	-	32.8 c	-	-	-	-	-	-	10.42	8.22
2	WF- No. of adult count per leaf	-	0.34	-	-	0.21	0.29	0.34	0.27	0.31	0.20	0.29	0.14	0.36	0.31	0.19	0.27	NS

LM = Leaf miner, WF = Whitefly

Figures followed by dissimilar letters are significantly different at 0.05

Table-10. Evaluation of four different tomato cultivars against Leaf miner, Whitefly and tomato yellow leaf curl virus and their impact on yield.

S. No.	Treatment (Cultivar)	Av. No. Of LM infested leaves per block	Av. No. of adult WF count per leaf	Effect of TYLCV On % fruit set up	Fruit yield	
					No.	Weight (Kgs)
1.	Niz - 63 - 308 F1	30.6	0.28	75.58 b	1066.25 a	87.7 b
2.	B- Ammariida	30.4	3.65	83.9 b	1024.00 a	94.9 b
3.	C- Pear Read	30.4	0.24	32.9 a	1858.25 a	33.15 a
4.	D- Sun Cherry	51.0	0.24	78.57 b	5175.50 b	72.55b
LSD $_{0.0.5}$		NS	NS	25.51	128.00	22.5

Figures followed by dissimilar letters are significantly different at 0.05

LM = Leaf miner, WF = Whitefly

Agro- Economic Assessment for Production of Cucumber Crop in Cooling and Non-Cooling Greenhouse

M.S.Al Rawahy, F.S. Al Raisy, S.M. Al Makhmary, S.M. Al Adawy and Ahmed .K Al Shidy
Ministry of Agriculture and Fisheries
Oman

Abstract

Hana F1 Cultivar was used to study the economics of cucumber production under cooling and non-cooling conditions during 2002-2003 Seasons at ARC. The total yield for two Seasons was 2076.1kg/gh and 2296 kg/gh for cooling greenhouse. In non-cooling greenhouse the yield in first season was 2536.9kg/gh the second crop was terminated due to high temperature. The input costs incurred in cooling greenhouse respectively for first and second seasons was R.O 286.8 and 276.8 with net profit of R.O 128.17 and R.O 182.41 while in non-cooling greenhouse the input cost for the first season was R.O 265.1 with a net profit of R.O 242.3.

Introduction

Cucumber is the most successful crop in protected Agriculture in the Sultanate of Oman. The yield of outstanding varieties can be improved by optimum husbandry practices. Considering the expensive cost of establishment and running of a cooling greenhouses during the season, and the potential of utilization of winter season (November –march) to produce Cucumber economically in non-evaporative cooling greenhouse with advantage of cutting cost of inputs such as electricity. This experiment was carried out to study the economical assessment of the year round production of cucumber under cooling greenhouse, and seasonal production in non-cooling greenhouses.

Materials and Methods

The experiment was conducted in two greenhouses of the same area (40m*9m), one greenhouse with evaporative cooling and the other one without evaporative cooling. The seeds of cucumber variety namely: Hana F1 were sown in jiffy pots on 18\9\02 and transplanted on 29\9\02 in a non-replicated plot in a two greenhouses as a first crop. The plants in the ventilated greenhouse were stressed and stunted due to high temperature that reached up to 40oC during noontime and therefore removed. Replanting was done on 19\11\02 by direct seeding for the first crop. The trial was continued for the second crop for the two greenhouses in which the seeds were sown directly on 2\2\03 in cooling greenhouse and sowing on 10\3\03 and transplanting on 22\3\03 in Non-cooling greenhouse. The spacing between plants was 50cm and the number of plants was 720 in each greenhouse. A drip irrigation system was used to irrigate the plants. The seedlings were irrigated daily for 10 minutes. The fertilizer was applied according to recommendation. The protection program was conducted by protection laboratory using IPPM program. The fruits were harvested twice a week. The number of fruits and fruit weight were recorded. Water requirement was measured. Inputs and yield were subjected to economical analysis.

Results

Table 1 presents the results of crop yield and yield component for the two seasons (Sept02-march 03) and (Feb-03-May-03) for the two greenhouses. The days to first harvest ranged from 42 for non-cooling greenhouse to 45 for cooling greenhouse. Whereas, the picking periods were 65 to 66 days for non-cooling and cooling greenhouses, respectively. The total yield produced by non-cooling greenhouse was (2.5t/gh) whereas cooling greenhouse gave (2.1t/gh) (Fig. 1). With regard to water consumption for the two greenhouses, non-cooling greenhouse consumed 40m3/gh while cooling greenhouse-consumed 42.1m3/gh. For the second crop, days to first harvest were 43 and the picking period continued for 49 days for cooling greenhouse. Total yield produced by cooling greenhouse was 2.3t/gh. Total amount of water consumed by cooling greenhouse was 24m3/gh. There were no data collected in non- cooling greenhouse as the crop was a complete failure due to high temperature rise (40oC) during day time. Table 2 shows the economic analysis for cucumber production in cooling and non- cooling greenhouse from (Sept02-march03) and (Feb03- May03). All the inputs were the same in the two greenhouses except charges toward electricity, which is an additional cost for cooling greenhouse. The total input cost was 286.8 and 276.8 Omani Rials for cooling greenhouse and 265.1 and 50 Omani Rials for non-cooling greenhouse. The price of one kilogram of cucumber is 0.2 Omani Rials at the mentioned seasons, so the total income for cooling greenhouse and non-cooling greenhouse was 415.2 and 459.2 Omani Rials and 507.38 Omani Rials respectively. The net profit for cooling greenhouse was 128.2 and 182.4 Omani Rials, and 242.3. Omani Rials, for non-cooling greenhouse (Fig. 2 and 3). There was no income for the non-cooling greenhouse during the second crop that was terminated due to high temperature.

Conclusion

In non-cooling greenhouse, cucumber can be successfully cultivated between October (last week) and April with yield similar to that produced in cooling greenhouse. Moreover, the non-cooling greenhouse is more economic during the winter season in comparison to cooling greenhouse because it excludes running cost-inputs such as electricity charges and the cost towards evaporating cooling system.

Table 1: Yield and yield components of Cucumber produced in cooling and non-cooling greenhouses at Agriculture Research Center

	First Crop		Second Crop	
Period	Sept-02-Jan03	Nov02-March03	Feb-May03	March03
Greenhouse(360m^2) yield component	Cooling	Non-cooling	Cooling	Non-cooling
Days to first harvest	45	42	43	Crop terminated due to high temperature
Harvest Period (Days)	66	65	49	
Number of plants/m^2	2	2	2	
Number of fruits/plant	29	29	16	
Number of fruits /gh	20646	20925	11422	
Yield kg/plant	2.9	3.5	3.2	
Yield kg/m^2	5.8	7.0	6.4	
Yield kg/gh	2075	2536.9	2296	
Yield t/gh	2.1	2.5	2.3	

Table 2: Economic analysis of cucumber production in cooling and non- cooling greenhouse from (Sept02-Jan03 and Nov02- March03) and (Feb-May03) at Agriculture Research Center

Items	First Crop			Second Crop		
	Greenhouses (360m^2)					
	Quantity	Cooling Cost	Non-Cooling Cost	Quantity	Cooling Cost	Non-Cooling
No. of Seeds	1000	50 R.O	50 R.O	1000	50 R.O	50 R.O
No. of Insect Traps	45	27 R.O	27 R.O	45	27 R.O	crop terminated due to high temperature 40^o C
Tobacco extract (kg)	4	4 R.O	4 R.O	8	8 R.O	
Urea (kg)	32	2.6 R.O	2.6 R.O	30	2.4 R.O	
Potassium Sulfate (kg)	5	0.7 R.O	0.7 R.O	5	0.7 R.O	
Electricity (kw)		35.19 R.O	-		35.19 R.O	
Water (m^3)	42-40	32.34 R.O	30.8	24	18.5R.O	
No. of Labor	1	135 R.O	135 R.O	1	135 R.O	
Inputs Cost R.O		286.8	265.1		276.8	
Income R.O		415	507.4		459.2	
Net Profit R.O		128.2	242.3		182.4	

*** Average fruit price during the season was 0.2 R.O**

Evaluation Of Growing Tomato (Lycopersicum Esculantum) In Soil-Less Techniques (Closed System) Under Cooled Greenhouse

Muthir Al Rawahy, Fatma Al Raisy, Salim Al Makhmary, Said Al Adawy and Ahmed Al Shidy
Ministry of Agriculture and Fisheries
Oman

Abstract

Four tomato varieties were evaluated in hydroponics (closed system) to study their performance in yield and quality under cooled greenhouse during 2002/2003 seasons at ARC. No significant differences were observed in the number of inflorescence, number of flowers and plant height after 14 weeks between Ammarida F1 and Niz F1. Significant differences were observed in the number of flowers and plant height after 14 weeks among the Cherry Varieties. The number of fruits ranged from 34.1 to 172.5. The yield ranged between 1.11 to 3.16 kg/plant. Total soluble solids varied from 10.3% to 11.3%.

Introduction

Protected cultivation of vegetables has been introduced recently in Oman. The number of greenhouses increased rapidly because many farmers started to realize the importance of this technology. The Ministry of Agriculture and Fisheries encouraged farmers to buy greenhouses by subsidizing 50% of the price of the greenhouse. Salinity is the major threat to the permanence of irrigated agriculture in arid and semi-arid regions of the world and Oman is no exception. In these areas unleashed soils (insufficient precipitation) are often saline as are available water resources and irrigation practices worsens the problem of salt build up. The process of gradual soil salinization and the preponderance of saline water source make us rely on soil-less techniques in vegetable production particularly under protected agriculture. Soil-less techniques offer a way of improving water use efficiency and obtaining better water and fertilizer management in vegetable production.

Materials and Methods

The seeds of four tomato varieties namely: Ammarida F1, Niz 63-308 F1 (Fresh type) sun cherry F1 and Red Pear F1 (Cherry type) were sown on 19\10\02 and transplanted on 17\11\02 in a CRD with four replication in hydroponics closed system. The greenhouse consists of eight channels, each channel 14m long and 35cm width, and the spacing between channels 1.64m .The number of plants in each channel was 60 plants making a total of 480 plants in eight channels. The plants were irrigated with nutrient solutions twice a day. The nutrient solution was prepared as follows Calcium Nitrate (SS1) 2.4 kg/40 liter water, NPK (Kristalon 12:12:36+ TE (SS2) 2.2kg /40 Liter water and Nitric acid (SS3) 1 liter/50 liter of water .The total amount of SS1, SS2 and SS3 applied were 72kg, 61.6 kg and 12 liter respectively .The electrical conductivity and pH were monitored throughout the course of the experiment. The system was automatically connected by a timer working and stops every 15 min during the day and every one-hour during the night. Three plants in each replication were taken as sample for measuring the plant height, number of inflorescence and number of flowers in each inflorescence every two weeks. The number of fruits and the fruit weight were recorded. Five fruits from each replication were taken to measure total soluble solids and to analyze nutrient concentration in the fruits (N, P, K, Mg and Ca) and heavy metals. The data were statistically analyzed using MstatC program.

Results

Vegetative growth: Significant differences were observed in the number of flowers and the plant height after 14 weeks between the cherry type tomatoes (Sun cherry and Red Pear) whereas, in the normal varieties (Ammarida F1 and Niz 63-308 F1) no significant differences were observed. The variety Niz 63-308 F1 gave the highest number of flowers per plant (99.7) and the highest plant height (268cm) while the number of inflorescences per plant was almost the same in the two varieties (normal type). Regarding the cherry type varieties Sun cherry F1 produced higher number of flowers per inflorescence (281.1) whereas Red pear gave the highest plant height (306.7cm) and the number of inflorescence per plant was almost the same in the Cherry type varieties (Table 1a and 1b).

Yield and yield components: The harvest period ranged from 68 days from transplanting for Red Pear F1 and Sun cherry F1 and 76 days for Ammarida F1 and Niz63-308 F1. The picking period continued for 71 days for Cherry type and 63 days for Ammarida F1 and Niz F1. The number of fruits was 34 and 36 for Ammarida F1 and Niz 36-308 F1 respectively, whereas in cherry tomatoes Red pear and Sun cherry the number was 62 and 172.5 respectively. High number of fruits were produced by Niz

63-308 F1 and Sun cherry F1 in normal and cherry type respectively. Significant differences in the fruit number between cherry varieties were observed whereas no significant differences among the normal type varities. Significant differences were obtained in the average fruit weight, total soluble solids and total yield between the varieties. However, no significant differences were found between Ammarida F1 and Niz 63-308 F1 for all parameters tested. Ammarida F1 92.3g and Red pear 19.0g were the heaviest fruit weight in the normal and cherry type tomatoes respectively. The total soluble solids varied from 10.3% for Ammarida F1 and 13.4 % for Sun cherry F1.The highest yield was produced by Ammarida F1 2.4t\gh and the lowest yield was produced by Niz63-308 F1 2.2t\gh in the normal type tomatoes and the trend was the same for the cherry type tomatoes Sun Cherry (1.8 t/gh) and Red pear (0.83 t/gh) (Table 2a and 2b). Figure 1 illustrates the comparison between the two normal varieties (Niz 63-308 F1 and Ammarida F1) in the number of flowers and yield. These results indicated that although the variety Niz 63-308 F1 gave higher number of flowers than Ammarida F1 (Table 1) it failed to produce fruits as many flowers were aborted, or infested by viruses. Whereas, in Ammarida F1 the yield was high because most of the flowers gave the fruits. Despite the low productivity of tomato observed in the present hydroponics system, preliminary economic analysis clearly indicated that the net profit was 576.7 O. R (fig.4. This profit was realized with fairly high costs of inputs, which can be substantially reduced in the future. (Table 3)

Fruit Nutrient Concentration in Hydroponics and Soil (Open Field): The elemental concentration of macro and micro nutrients of tomato fruit shown in Figures 2 and 3 are comparable although the hydroponics reflected higher concentration in some elements compared to the soil (open field). This is natural because the hydroponics was under controlled condition. It is worth-mentioning that both concentrations were safe to human consumption.

Table 1a: Flowering and growth parameters of normal tomato varieties grown in hydroponics (closed system) at Agriculture Research Center during 2002/2003 season.

Variety	No. of inflorescence/plant	Flower no./ inflorescence	Height after 14 weeks (cm)
Niz 63-308F1	15.9	99.7	268.3
Ammarida F1	15.1	63.5	239.4

L.S.D at 0.05 NS 34.8 NS

Table 1b: Flowering and growth parameters of cherry tomato varieties grown in hydroponics (closed system) at Agriculture Research Center during 2002/2003 season.

Variety	No. of inflorescence/plant	Flower no./ inflorescence	Height after 14 weeks (cm)
Sun cherry F1	20.2	281.1	268.1
Red pear F1	21.1	167.1	306.7

L.S.D at 0.05 NS 34.8 NS

Table 2a: Yield and yield components of normal tomato varieties grown in hydroponics (closed system) at Agriculture Research Center during 2002/2003 season.

Varieties	Total no. of Fruits /plant	Avg. fruit wt (g)	TSS%	Yield kg/plant	Yield kg/m^2	Yield t/gh
Ammarida F1	36	92.3	10.3	3.16	8.75	2.4
Niz63-308 F1	34	84.2	10.4	2.92	8.1	2.2

LSD 0.05 NS NS NS NS NS NS

Table 2b: Yield and yield components of cherry tomato varieties grown in hydroponics (closed system) at Agriculture Research Center during 2002/2003 season.

Varieties	Total no. of Fruits /plant	Avg. fruit wt g	TSS%	Yield kg/plant	Yield kg/m^2	Yield t/gh
Sun cherry F1	172.5	14.0	13.4	2.4	6.7	1.8
Red pear F1	62	19.0	11.3	1.1	3.1	0.83

LSD 0.05 36.7 4.7 0.24 0.6 1.6 0.45

Table 3: Economic analysis of production inputs of tomato crop grown in hydroponics system at ARC

Items	Quantity	Cost in R. O
Plastic rolls	2.5	27.5
Agrill rolls (m)	15	.75
No. of Seeds	1000	6
No. of Insect traps	45	27
Calcium nitrate (bags)	3	15
Kristalon (bags)	2.5	20
Nitric acid (Liters)	5	7.5
Electricity kw/day	149.5	210
Water m^3	207.3	159.6
No. of Labor	1	150
Inputs cost	-	623.4
Total Income	-	1200
Net profit	-	576.7

Average fruit price \kg for hydroponics products =0.5 R.O.

Evaluation of growing Cucumber in Soil-less Culture (sand media) under cooled greenhouse

M Muthir Al Rawahy, Fatma Al Raisy, Salim Al Makhmary, Said Al Adawy and Ahmed Al Shidy
Ministry of Agriculture and Fisheries
Oman

Abstract

The Cucumber variety namely; Printo F1 was grown to evaluate the yield and the quality of the produce in a sand media (open system) under cooled greenhouse during summer season (June-Sept.03) at Rumais Research station. The total number of fruits was 6011 whereas the total yield recorded was 823.6 kg/gh.

Introduction

Protected cultivation of vegetables has been introduced recently in Oman. The number of greenhouses increased rapidly because many farmers started to realize the importance of this technology. The Ministry of Agriculture and Fisheries encouraged farmers to buy greenhouses by subsidizing 50% of the price of the greenhouse. Salinity is the major threat to the permanence of irrigated agriculture in arid and semi-arid regions of the world and Oman is no exception. In these areas unleashed soils (insufficient precipitation) are often saline as are available water resources and irrigation practices worsens the problem of salt build up. The process of gradual soil salinization and the preponderance of saline water source make us rely on soil-less techniques in vegetable production particularly under protected agriculture. Soil-less techniques offer a way of improving water use efficiency and obtaining better water and fertilizer management in vegetable production.

Materials and Methods

The trial was conducted in a cooled greenhouse with an area of 270m2 (30m x 9m). Wadi sand was used as a media for growing cucumber. Electrical conductivity (ECe) of the sand was 4.3ds/m and the pH was 7.5.The greenhouse was divided into five channels and the channels were first covered with white agril then filled with wadi sand. The seeds were sown on 3/6/03 in a jiffy pots and transplanted on 22\6\03, in a non replicated plots. The spacing between plants was 50cm and the number of plants in each line was 100 with a total of 500 plants in five lines. A drip irrigation system was used to irrigate the plants for 10 minutes four times a day with a drip discharge of 3.3 l/h. Commercial ready made fertilizers were used to formulate a nutrient solution. The amount of the fertilizer used was as follows: 15 kg/ gh of NPK 20:20:20 fertilizer was applied for four weeks and 20kg\gh of NPK 12:12:36 fertilizer, after first harvest till end of the experiment. The total amount of fertilizer applied was 35 kg/gh and the total amount of water consumed was 84m3/gh. Protection measures were done by protection section using IPPM program. Harvesting was stared on 26/7/03 and the crop was harvested twice a week. The number and the weight of fruits were recorded.

Results

The number of days to the first harvest and the harvest period were 35 and 39 days respectively. The total number of fruits was 6011 and the average fruit weight was 114.2g whereas the total yield was 0.83t/gh (Table 1). Although the yield was low during this period due to high temperature (33.3 to 38.1oC) (Table 2), the price of cucumber in the market was high amounting to 0.3 Omani Rial per kilogram of cucumber.

Table 1: Yield components and yield of cucumber crop grown in sand media (open system) at Agriculture Research Center during summer (June – Sept03).

Variety	First harvest (Days)	Harvest period (Days)	Total number of fruits	Average fruit weight (g)	Yield kg\plant	Yield kg/gh	Yield t/gh
Printo F1	35	39	6011	114.2	1.65	823.6	0.824

Data not statistically analyzed

Table 2: Average daily air temperatures in side cooling greenhouse during 2003 Season

Month	Average air temperature (^{o}C)
June	38.1
July	34.9
August	33.3
September	34.3