Establishment of Field Genebank of Indigenous Pasture Plant Species of Oman

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Abstract

Establishment of a field genebank of indigenous pasture plant species of Oman was initiated in an area of about 1 ha at Agriculture Research Center, Rumais during October 2004. A list of pasture plant species was prepared based on the information gathered from the several interviews with herders during several collection missions and the literature on flora and fauna of Oman. The list included a total of 244 pasture plant species belonging to 178 genera and 54 families. These pasture plant species include 73 herb, 71 shrub, 38 tree and 62 monocotyledonous grass species. The layout of field genebank was prepared based on plant type viz. herb, shrub, tree and grass species. It was planned to keep four plants each of herbs, shrubs and trees in 3 m long two rows spaced 2 m apart while four plants each of grass species in single 3 m long rows spaced 1 m apart. Initial planting of available plants at shade house that covers as many as 32 % of species was done during October 2004. The plants of those species that are not available at present will be collected during future collection missions and planted at their respective spaces in the field genebank. This field genebank will be first of its kind in Oman towards conservation of indigenous pasture plants. The indigenous rangeland pasture plant species are used phase-wise on priority for characterization and seed multiplication (basic and bulk) to re-seed in the degraded rangelands.

Introduction

Field genebanks of any plant species be it of forage to food value, could be considered as national asset to the country towards maintaining its bio-diversity. They would be beneficial to the country in terms of conservation and utilization of indigenous germplasm to meet objectives of several issues on bio-diversity. Collection missions of indigenous germplasm are frequently organized to collect propagation material of plant species viz. seed, rhizomes, suckers, cuttings, bulbs etc for *Ex Situ* conservation in the laboratory or in the field and further utilization. Several collections missions were organized in the past by the Ministry of Agriculture & Fisheries to collect indigenous germplasm of field and forage crops during 1980's. The collection missions for rangeland germplasm concerning forage 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 mission was guided by the list of target species prepared based on our interviews with herders and farmers rearing livestock. 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. 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. In order to establish field genebank of pasture plant species, a list of pasture plant species was prepared based on the information gathered from the several interviews with herders during collection missions and the literature on flora and fauna of Oman. The list included a total of 244 pasture plant species belonging to 178 genera and 54 families (Table 1). These pasture plant species included 73 herb, 71 shrub, 38 tree and 62 monocotyledonous grass species. The layout of field genebank of was prepared on the basis of plant type viz. herb (Table 2 (a)), shrub (Table 2 (b)), tree (Table 2 (c)) and grass species (Table 2 (d)). It was arranged to keep four plants each of herbs, shrubs and trees in 3 m long two rows spaced 2 m apart while four plants each of grass species in single 3 m long rows spaced 1 m apart. Initial planting of available plants at shade house that covers as many as 32 % of plant species was done during October 2004. The plants of those taxa that are not available at present will be collected during future collection missions and planted at their respective sites in the field genebank. This field genebank will be first of its kind in Oman towards conservation of indigenous pasture plants.
The indigenous rangeland pasture plant species are used phase-wise on priority for characterization and seed multiplication (basic and bulk) to re-seed in the degraded rangelands.

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Table 1. Field Gene Bank -Pasture Plant Species Of Oman

FAMILY/ SPECIES	SCIENTIFIC NAME	VERNACULAR NAME	PLANT TYPE
1. Acanthaceae			
	Barleria hochstetteri	*thefied*	Shrub
	Blepharis ciliaris	*nigeyl*	Shrub
	Blepharis dhofarensis	*alib, alyib, ilob, ayzob*	Tree
	Blepharis linariifolia	*asker e da'an, sebbin*	Herb
	Dyschoriste dalyi	*dafed*	Herb (creeper)
2. Agavaceae			
	Dracaena serrulata	*ariyeb, ayrob*	Tree
3. Aizoaceae			
	Aizoon canariens	*shuheymat ard*	Herb
4. Amaranthaceae			
	Achyranthes aspera	*harsha*	Herb
	Aerva javaniea	*ra, a'raa*	Shrub
	Amaranthus graeazans	*dadh, quttaif, shegratal santeen, sindar*	Herb
	Amaranthus viridis	*sindar, arf al-deek*	Herb
5. Anacardaceae			
	Rhus aucheri	*Qataf*	Tree
6. Asclepiadaceae			
	Leptadenia pyrotechnica	*moorakh, markh*	Shrub
	Periplocal aphylla	*handabub*	Shrub
7. Boraginaceae			
	Arnebia hispidissima	*habrak*	Herb
	Heliotropium calcareum	*khashafa*	Herb
	Heliotropium digynum	*khashafa*	Herb
	Heliotropium europaeum	*shajarat al busha*	Herb
	Heliotropium kotschyi	*rumram*	Shrub
8. Caesalpiniaceae			
	Delonix elata	*erer, erir*	Tree
	Senna italica	*ashriq*	Shrub
9. Capparaceae			
	Boscia arabica	*sir*	Tree
	Cadaba baccarinii	*surhah, sirmar*	Shrub
	Cadaba farinosa	*surhah, sirmar*	Shrub
	Capparis cartilaginea	*lezaf*	Shrub
	Capparis spinosa	*lezaf*	Shrub
	Dipterygium glaucum	*alga*	Shrub
	Maerua crassifolia	*sarh*	Tree
10. Caryophyllaceae			
	Gymnocarpus decandrum	*	Shrub
	Paronychia arabica	*razal al hamam*	Shrub
11. Celastraceae			
	Maytenus dhofarensis	*	Shrub
	Maytenus senegalensis	*	Tree
12. Chenopodiaceae			
	Arthrocnemum macro stachyum	*hamad*	Shrub
	Bassia muricata	*lahya at taish*	Herb
	Chenopodium album	*harush shola*	Herb
	Chenopodium murale	*al dhorbai, al zorbai*	Herb
	Cornulaca monacantha	*ha'ath*	Shrub
	Halopeplis perfoliata	*gharaz*	Shrub
	Hammada elegans	*rymth*	Shrub
	Salicornia herbacea	*khariza*	Herb
	Salsola baryosma	*khaderaaf, arad*	Shrub
	Salsola rubescens	*khumkham*	Shrub
	Sueda aegyptiaca	*soowad*	Shrub
	Sueda vermiculata	*soowad*	Shrub
13. Cistaceae			
	Helianthemum lippi	*biqan, ruqruq*	Shrub
14. Cleomaceae			
	Cleome amblyocarpa	*mukhaisha*	Shrub
	Cleome aff. Dolichostyla	*mukhaisha*	Shrub
	Cleome glaucescens	*muqaybil as shams*	Herb
15. Combretaceae			
	Anogeissus dhofarica	*misteh, Meset*	Tree
16. Compositae			
	Blepharispermum hirtum	*xfot*	Tree
	Echinops spinosissimus	*qan'a, kan'a*	Shrub
	Launaea mucronata	*athaida, huwwa*	Herb
	Launaea nudicaulis	*huwwa*	Herb
	Reichardia tingitana	*huwwahtlil-wail*	Herb

	Rhanterium epapposum	*arfaz*	Shrub
	Sonchus oleraceus	*hodeid, hawwa, khuwaysh*	Shrub
17. Coniferophyta			
	Juniperus excelsa	*al alan*	Tree
18. Convolvulaceae			
	Convolvulus arvensis	*fadakh, mulawwiya, maddaid*	Herb
	Convolvulus cephalopodus	*fadakh, mulawwiya, maddaid*	Herb
	Convolvulus pilosellifolius	*faaghi, rukham, bia'd*	Shrub
	Convolvulus prostatus	*hathma*	Shrub
	Convolvulus virgatus	*hibab risha*	Shrub
	Cressa cretica	*schwayla*	Shrub
19. Cruciferae			
	Brassica tournefortii	*harsha', khardala*	Herb
	Diplotaxis harra	*khawshyan*	Herb
	Eruca sativa	*zarzir*	Herb
	Erucaria hispanica	*asma'an, khaza'm*	Herb
	Farsetia aegyptica	*masharri, hibab*	Herb
	Farsetia linearis	*masharri, hibab*	Herb
	Morettia parviflora	*hafra*	Herb
	Phsorrhynchus chamaerapistrum	*kawfig, kafij*	Herb
	Sisymbrium irio	*huwaira*	Herb
20. Cucurbitaceae			
	Citrulus colocynthis	*handal*	Herb
21. Cyperaceae			
	Cyperus conglomeratus	*ankood, thanda, qasb arrumal*	Herb (Grass)
	Cyperus rotundus	*sa'd, sa'd al hammar*	Herb (Grass)
22. Ebenaceae			
	Euclea schimperi	*kilit*	Shrub
23. Euphorbiaceae			
	Andracne teleiodes	*kubdanayt*	Herb
	Chrozophora oblongifolia	*tannum, tinib*	Shrub
	Euphorbia balsamifera	*tikedoha, tiskot, tehekot*	Shrub
	Euphorbia granulata	*herem d ezen*	Herb
	Euphorbia larica	*isbaq*	Shrub
	Euphorbia peplus	*lubaina qaiima*	Herb
	Euphorbia prostrata	*lubaina zahafa*	Herb
	Euphorbia riebeckii	*gisherib*	Shrub
24. Fabaceae			
	Alhagi maurorum	*agool, agul*	Shrub
	Astragalous fasciculifolius	*aanora*	Shrub
	Ceratonia oreothauma sub sp oreothauma	*tiyu*	Tree
	Crotalaria aegyptiaca	*nizaar*	Shrub
	Crotalaria persica	*nizaar, hayk, khaiz*	Shrub
	Crotalaria retusa	*Nizaar sageer*	Herb
	Ebinus stellata	*jardan, kalban, kumil*	Shrub
	Indigofera argentea	*shajratal arnep, bisha, neela*	Herb
	Indigofera articulata	*shajratal arnep, bisha, neela*	Herb
	Indigofera oblogifolia	*ahsit, homeer, neela*	Herb
	Melilotus alba	*handakok*	Herb
	Melilotus indicus	*handakok*	Herb
	Ormocarpum dhofarense	*ximer, xir*	Shrub
	Tamarindus indica	*sabbar, areyr, tur hindi*	Tree
	Taverniera cuneifolia	*asmat, wardal jabal*	Shrub
	Taverniera glabra	*asmat*	Shrub
	Taverniera spartea	*asmat, gus*	Shrub
	Tephrosia apollinea	*dhafra*	Shrub
	Trigonella hamosa	*gitaita, qutaifa, rotha*	Herb
	Trigonella hamulosa	*gitaita, qutaifa, rotha*	Herb
	Trigonella stellata	*gitaita, qutaifa, rotha*	Herb
	Vigna radiata var sublobata	*	Herb
25. Geraniaceae			
	Monsonia heliotropioides	*shajaratal ghul*	Shrub
	Monsonia nivea	*shajaratal ghul*	Herb
26. Gramineae			
	Aeluropus lagopoides	*Akarish*	Grass
	Apluda mutica	*	Grass
	Aristida adscensions	*lihyat al tays*	Grass
	Aristida mutabilis	*swayd ghamar*	Grass
	Arthraxon lancifoilus	*rihiet*	Grass
	Avena barbata	*shufan barri*	Grass
	Brachiaria erusiformis	*naamait*	Grass
	Cenchrus ciliaris	*sabat, lubayat*	Grass
	Cenchrus pennisetiformis	*khadar*	Grass
	Cenchrus setigerus	*Sabat*	Grass
	Centropodia forssakli	*	Grass
	Chloris plumosus	*gharaz*	Grass
	Chloris virgata	*khajamjam, smaima*	Grass

	Coelacyrum piercei	*a'dhukna*	Grass
	Cutandia memphitica	*	Grass
	Cymbopogon schoenanthus	*Sakhbar*	Grass
	Cynodon dactylon	*theel, nagel*	Grass
	Dactyloctenuim aegyptium	*abu asabie, thayil, najil*	Grass
	Dactyloctenuim scindicum	*abu asabie, thayil, najil*	Grass
	Dichanthium annulatum	*zidrot, gheferait*	Grass
	Dichanthium aristatum	*zidrot, gheferait*	Grass
	Dichanthium faveolatum	*rokkos*	Grass
	Dichanthium micranthum	*zidrot, gheferait*	Grass
	Digitaria sanguinalis	*dafira, difra*	Grass
	Echinochloa colona	*abu rokba, dineiba, zarra*	Grass
	Eleusine indica	*ayyal, snaima, hamra*	Grass
	Eragrostis barrelieri	*naamait*	Grass
	Eragrostis cilianensis	*fitha, tirab*	Grass
	Eragrostis ciliaris	*suwed ghamir*	Grass
	Halopyrum mucronatum	*	Grass
	Lasiurus hirsutus	*a'dhaiy*	Grass
	Lolium rigidum	*hibiya'n*	Grass
	Loudetia flavida	*airmot*	Grass
	Ochthochola compressa-Annual	*aila*	Grass
	Panicum antidotale	*	Grass
	Panicum atrosanguineum	*	Grass
	Panicum coloratum	*	Grass
	Panicum maximum	*	Grass
	Panicum trichoides	*	Grass
	Panicum turgidum	*thumam*	Grass
	Pennisetum divisum	*thumam*	Grass
	Pennisetum orientale	*Khashna, qasis*	Grass
	Pennisetum setaceum	*halfa*	Grass
	Phragmites australis	*hazeer*	Grass
	Polypogon monospeliensis	*Thail alqat*	Grass
	Setaria intermedia	*lislis*	Grass
	Setaria pumila	*arayt, lislis, dhenob, ithaet*	Grass
	Setaria verticillata	*aseeq*	Grass
	Setaria viridis	*assaq, luseeq, shar al faar, zail al faar*	Grass
	Sporobolus arabicus	*	Grass
	Sporobolus ioclades	*halfa, dafra, gazaza*	Grass
	Sporobolus nervosus	*halfa*	Grass
	Sporobolus spicatus	*halfa*	Grass
	Sporobolous virginicus	*halfa*	Grass
	Stipagrostis ciliata	*nusee'a, halta'a, sama'a*	Grass
	Stipagrostis plumosa	*nusee'a, halta'a, sama'a*	Grass
	Stipagrostis raddiana	*nusee'a, halta'a, sama'a*	Grass
	Themeda quadrivalis	*eli*	Grass
27. Juncaceae			
	Juncus rigidus	*hadaf, smar, asil*	Grass
28. Labiatae			
	Leucas inflata	*qotnya*	Shrub
29. Liliaceae			
	Asphodelus fistulosus var. tenuifolius		Herb
30. Malpighiaceae			
	Acridocarcarpus orientalis	*qafas*	Shrub
31. Malvaceae			
	Abutilon pannosum	*munnaqa'*	Herb
	Malva parviflora	*shuwayb al hamam*	Herb
	Sida urens	*kassh rai*	Herb
32. Mimosaceae			
	Acacia ehrenbergiana	*salam*	Tree
	Acacia etbaica	*samra*	Tree
	Acacia gerardi	*tulh*	Tree
	Acacia laeta	*temrit*	Tree
	Acacia nilotica (arabica)	*qarat*	Tree
	Acacia oerfota	*harheyr*	Shrub
	Acacia senegal	*thor*	Tree
	Acacia tortilis	*Samar*	Tree
	Leucaena leu'cocephala	*leusanaa*	Shrub
	Pithecellobium dulce	*gaaf al bahr, kuzooh*	Tree
	Prosopis cineraria	*gaaf*	Tree
33. Moraceae			
	Ficus cordata sub sp. salicifolia	*lithab*	Tree
	Ficus lutea	*derfit, zerfit*	Tree
	Ficus palmata	*siqab, thiqab*	Tree
	Ficus sycomorus	*geydeh, gizit*	Tree
	Ficus vasta	*teyk, tik*	Tree

34. Moringaceae			
	Moringa peregrina	*shua'*	Tree
35. Nyctaginaceae			
	Boerhavia elegans	*hahimdan*	Herb
	Boerhavia repens	*hahimdan*	Herb
	Commicarpus boisseri	*Aytif*	Herb
	Commicarpus helenae	*Aytif*	Herb
36. Oleaceae			
	Olea europaea	*itm*	Tree
37. Plantaginaceae			
	Plantago amplexicaulis	*yan-nam, rabl'*	Herb
	Plantago boissieri	*yan-nam, rabl'*	Herb
	Plantago ciliata	*yan-nam, rabl'*	Herb
38. Plumbaginaceae			
	Dyerophytum indicum	*Malihla*	Shrub
39. Polygonaceae			
	Calligonum comosum	*arta'*	Shrub
	Calligonum criniticum	*	Herb
	Emex spinosus	*lissan alqalb, henjab*	Herb
	Polygala erioptera	*Ghazema*	Herb
	Polygala muscatense	*Ghashaish*	Herb
	Pteropyrum scorpium	*Sidaf*	Shrub
	Rumex vesicarius	*Hummad*	Herb
40. Portulacaceae			
	Portulaca oleracea	*barbir, baklah, nijla, rigla*	Herb
41. Primulaceae			
	Anagallis arvensis	*Ain al qat, al quina, uwaynah, zraig al ain*	Herb
42. Resedaceae			
	Ochradenus arabicus	*qurliya, asmat, hibab*	Shrub
	Ochradenus aucheri	*asa al jabal*	Shrub
	Reseda aucheri	*Zinban*	Shrub
	Reseda muricata	*Zinban*	Shrub
43. Rhamnaceae			
	Rhamnus studdo	*hagor mitayn*	Tree
	Sagetaria spiciflora	*Nimth*	Shrub
	Ziziphus leucodermis	*cider, nabaq, nabaz*	Tree
	Ziziphus mauritania (Jujube)	*cider, nabaq*	Tree
	Ziziphus spina-christi	*cider, nabaq, nabaz*	Tree
44. Rubiaceae			
	Jaubertia aucheri	*Khurman*	Shrub
45. Salvadoraceae			
	Salvadora persica	*raa'q*	Shrub
46. Sapindaceae			
	Allophylus rubifolius	*Zerkim*	Tree
	Dodonaea angustifolia	*Sires*	Shrub
	Dodonaea viscosa	*Shahs*	Shrub
47. Sapotaceae			
	Monotheca buxifolia	*But*	Tree
48. Solanaceae			
	Lycium shawii	*Qasad*	Tree
	Solanum incanum	*Shrinjiban*	Herb
	Solanum nigrum	*anab deeb*	Herb
	Withania somnifera	*babu, sim alfa'r*	Herb
49. Tamaricaceae			
	Tamarix aphylla	*athal, tarfa*	Tree
50. Tiliaceae			
	Grewia darmine	*Gared*	Shrub
	Grewia erythraea	*sharham*	Shrub
51. Umbelliferae			
	Ammi majus	*naynia*	Herb
	Anethum graveolens	*	Herb
	Pycnocycla caespitosa	*kalfayt*	Shrub
52. Urticaceae			
	Forsskaolea tenalissima	*melazaq, lazzaq*	Herb
53. Verbenaceae			
	Avicennia marina	*qurm*	Tree
	Premna resinosa	*sohit, sebhit*	Shrub
54. Zygophyllaceae			
	Fagonia bruguierei	*durayma*	Herb
	Fagonia indica	*shuka'*	Shrub
	Fagonia ovalifolia	*shaja'a, akarish*	Herb
	Seetzenia lanata	*habiyan, abu shoka*	Herb
	Tribulus omanense	*jahar, qatab, hasaq, drees*	Herb
	Zygophyllum hamiense	*haram*	Herb
	Zygophyllum qatarense	*theromet*	Shrub
	Zygophyllum simplex	*jareejh, qarmal*	Herb

Table 2(a). Layout of herb species in field genebank of pasture plants of Oman in five columns each containing 15 plant species

HERBS

I	II	III	IV	V
15. Cleomaceae ***Cleome glaucescens*** *muqaybil as shams*	16. Compositae ***Launaea mucronata*** *athaida, huwwa*	45. Malvaceae ***Abutilon pannosum*** *munnaqa'*	*46. Malvaceae* ***Malva parviflora*** *shuwayb al hamam*	
14. Chenopodiaceae ***Salicornia herbacea*** *khariza*	17. Compositae ***Launaea nudicaulis*** *huwwa*	44. Geraniaceae ***Monsonia nivea*** *shajaratal ghul*	*47. Malvaceae* ***Sida urens*** *kassh rai*	
13. Chenopodiaceae ***Chenopodium murale*** *al dhorbai, al zorbai*	18. Compositae ***Reichardia tingitana*** *huwwahtlil-wail*	43. Fabaceae ***Vigna radiata var sublobata*** *	*48. Nyctaginaceae* ***Boerhavia elegans*** *hahimdan*	73. Zygophyllaceae ***Zygophyllum simplex*** *jareejh, qarmal*
12. Chenopodiaceae ***Chenopodium album*** *harush shola*	19. Convolvulaceae ***Convolvulus arvensis*** *fadakh, mulawwiya, maddaid*	42. Fabaceae ***Trigonella stellata*** *gitaita, qutaifa, rotha*	*49. Nyctaginaceae* ***Boerhavia repens*** *Kissit al-rai, hahimdan*	72. Zygophyllaceae ***Zygophyllum hamiense*** *haram*
11. Chenopodiaceae ***Bassia muricata*** *lahya at taish*	20. Convolvulaceae ***Convolvulus cephalopodus*** *fadakh, mulawwiya, maddaid*	41. Fabaceae ***Trigonella hamulosa*** *gitaita, qutaifa, rotha*	*50. Nyctaginaceae* ***Commicarpus boisseri*** *aytif*	71. Zygophyllaceae ***Tribulus omanense*** *jahar, qatab, hasaq, drees*
10. Boraginaceae ***Heliotropium europaeum*** *shajarat al busha*	21. Cruciferae ***Brassica tournefortii*** *harsha', khardala*	40. Fabaceae ***Trigonella hamosa*** *gitaita, qutaifa, rotha*	*51. Nyctaginaceae* ***Commicarpus helenae*** *Aytif*	70. Zygophyllaceae ***Seetzenia lanata*** *habiyan, abu shoka*
9. Boraginaceae ***Heliotropium digynum*** *khashafa*	22. Cruciferae ***Diplotaxis harra*** *khawshyan*	39. Fabaceae ***Melilotus indicus*** *handakok*	*52. Plantaginaceae* ***Plantago amplexicaulis*** *yan-nam, rabl'*	69. Zygophyllaceae ***Fagonia ovalifolia*** *shaja'a, akarish*
8. Boraginaceae ***Heliotropium calcareum*** *khashafa*	23. Cruciferae ***Eruca sativa*** *zarzir*	38. Fabaceae ***Melilotus alba*** *handakok*	*53. Plantaginaceae* ***Plantago boissieri*** *yan-nam, rabl'*	68. Zygophyllaceae ***Fagonia bruguierei*** *durayma*
7. Boraginaceae ***Arnebia hispidissima*** *habrak, kahil*	24. Cruciferae ***Erucaria hispanica*** *asma'an, khaza'm*	37. Fabaceae ***Indigofera oblogifolia*** *sahah'*	*54. Plantaginaceae* ***Plantago ciliata*** *yan-nam, rabl'*	67. Urticaceae ***Forsskaolea tenalissima*** *melazaq, lazzaq*
6. Amaranthaceae ***Amaranthus viridis*** *sindar, arf al-deek*	25. Cruciferae ***Farsetia aegyptica*** *masharri, hibab*	36. Fabaceae ***Indigofera articulata*** *shajratal arnep, bisha, neela*	*55. Polygonaceae* ***Calligonum criniticum*** *arta*	66. Umbelliferae ***Anethum graveolens*** *
5. Amaranthaceae ***Amaranthus graeazans*** *dadh, quttaif, shegratal santeen, sindar*	26. Cruciferae ***Farsetia linearis*** *masharri, hibab*	35. Fabaceae ***Crotalaria retusa*** *nizaar sageer*	*56. Polygonaceae* ***Emex spinosus*** *lissan alqalb, henjab*	65. Umbelliferae ***Ammi majus*** *naynia*
4. Amaranthaceae ***Achyranthes aspera*** *harsha*	27. Cruciferae ***Morettia parviflora*** *hafra*	34. Euphorbiaceae ***Euphorbia prostrata*** *lubaina zahafa*	*57. Polygonaceae* ***Polygala erioptera*** *ghazema*	64. Solanaceae ***Withania somnifera*** *babu, sim alfa'r*
3. Aizoaceae ***Aizoon canariens*** *shuheymat ard*	28. Cruciferae ***Phsorrhynchus chamaerapistrum*** *kawfig, kafij*	33. Euphorbiaceae ***Euphorbia peplus*** *lubaina qaiima*	*58. Polygonaceae* ***Polygala muscatense*** *ghashaish*	63. Solanaceae ***Solanum nigrum*** *anab deeb*
2. Acanthaceae ***Dyschoriste dalyi*** *dafed*	29. Cruciferae ***Sisymbrium irio*** *huwaira*	32. Euphorbiaceae ***Euphorbia granulata*** *herem d ezen*	*59. Polygonaceae* ***Rumex vesicarius*** *hummad*	62. Solanaceae ***Solanum incanum*** *shrinjiban*
1. Acanthaceae ***Blepharis linariifolia*** *asker e da'an, sebbin*	30. Cucurbitaceae ***Citrulus colocynthis*** *handal*	31. Euphorbiaceae ***Andracne teleiodes*** *kubdanayt*	60. Portulacaceae ***Portulaca oleracea*** *barbir, baklah, nijla, rigla*	61. Primulaceae ***Anagallis arvensis*** *ain al qat, al quina, uwaynah, zraig al ain*

Table 2(b). Layout of shrub species in field genebank of pasture plants of Oman in five columns each containing 15 plant species

SHRUBS

VI	VII	VIII	IX	X
15. Celastraceae ***Maytenus dhofarensis*** *	16. Chenopodiaceae ***Arthrocnemum macrostachyum*** *hamad*	45. Fabaceae ***Taverniera cuneifolia*** *Asmat, wardal jabal*	46. Fabaceae ***Taverniera glabra*** *asmat*	
14. Caryophyllaceae ***Paronychia arabica*** *razal al hamam*	17. Chenopodiaceae ***Cornulaca monacantha*** *ha'ath*	44. Fabaceae ***Ormocarpum dhofarense*** *Ximer, xir*	47. Fabaceae ***Taverniera spartea*** *asmat, gus*	
13. Caryophyllaceae ***Gymnocarpus decandrum*** *	18. Chenopodiaceae ***Halopeplis perfoliata*** *gharaz*	43. Fabaceae ***Ebinus stellata*** *Jardan, kalban, kumil*	48. Fabaceae ***Tephrosia apollinea*** *dhafra*	
12. Capparaceae ***Dipterygium glaucum*** *alga*	19. Chenopodiaceae ***Hammada elegans*** *rymth*	42. Fabaceae ***Crotalaria persica*** *Nizaar, hayk, khaiz*	49. Geraniaceae ***Monsonia heliotropioides*** *shajaratal ghul*	
11. Capparaceae ***Capparis spinosa*** *lezaf*	20. Chenopodiaceae ***Salsola baryosma*** *khaderaaf, arad*	41. Fabaceae ***Crotalaria aegyptiaca*** *Nizaar*	50. Labiatae ***Leucas inflata*** *qotnya*	71. Zygophyllaceae ***Zygophyllum qatarense*** *theromet*
10. Capparaceae ***Capparis cartilaginea*** *lezaf*	21. Chenopodiaceae ***Salsola rubescens*** *khumkham*	40. Fabaceae ***Astragalous fasciculifolius*** *Aanora*	51. Malpighiaceae ***Acridocarcarpus orientalis*** *qafas*	70. Zygophyllaceae ***Fagonia indica*** *shuka'*
9. Capparaceae ***Cadaba farinosa*** *surhah, sirmar*	22. Chenopodiaceae ***Sueda aegyptiaca*** *soowad*	39. Fabaceae ***Alhagi maurorum*** *Agool, agul*	52. Mimosaceae ***Acacia oerfota*** *harheyr*	69. Verbenaceae ***Premna resinosa*** sohit, sebhit
8. Capparaceae ***Cadaba baccarinii*** *surhah, sirmar*	23. Chenopodiaceae ***Sueda vermiculata*** *soowad*	38. Euphorbiaceae ***Euphorbia riebeckii*** *Gisherib*	53. Mimosaceae ***Leucaena leu'cocephala*** *leusanaa*	68. Umbelliferae ***Pycnocycla caespitosa*** *kalfayt*
7. Caesalpiniaceae ***Senna italica*** *ashriq*	24. Cistaceae ***Helianthemum lippi*** *biqan, ruqruq*	37. Euphorbiaceae ***Euphorbia larica*** *Isbaq*	54. Plumbaginaceae ***Dyerophytum indicum*** *malihla*	67. Tiliaceae ***Grewia erythraea*** *sharham*
6. Boraginaceae ***Heliotropium kotschyi*** *rumram*	25. Cleomaceae ***Cleome amblyocarpa*** *mukhaisha*	36. Euphorbiaceae ***Euphorbia balsamifera*** *Tikedoha, tiskot, tehekot*	55. Polygonaceae ***Calligonum comosum*** *arta'*	66. Tiliaceae ***Grewia darmine*** *gared*
5. Asclepiadaceae ***Periploca aphylla*** *handabub*	26. Cleomaceae ***Cleome aff. Dolichostyla*** *mukhaisha*	35. Euphorbiaceae ***Chrozophora oblongifolia*** *tannum, tinib*	56. Polygonaceae ***Pteropyrum scorpium*** *sidaf*	65. Sapindaceae ***Dodonaea viscosa*** *shahs*
4. Asclepiadaceae ***Leptadenia pyrotechnica*** *moorakh, markh*	27. Compositae ***Echinops spinosissimus*** *qan'a, kan'a*	34. Ebenaceae ***Euclea schimperi*** *kilit*	57. Resedaceae ***Ochradenus arabicus*** *qurliya, asmat, hibab*	64. Sapindaceae ***Dodonaea angustifolia*** *sires*
3. Amaranthaceae ***Aerva javanica*** *ra, a'raa*	28. Compositae ***Rhanterium epapposum*** *arfaz*	33. Convolvulaceae ***Cressa cretica*** *schwayla*	58. Resedaceae ***Ochradenus aucheri*** *asa al jabal*	63. Salvadoraceae ***Salvadora persica*** *raa'q*
2. Acanthaceae ***Blepharis ciliaris*** *nigeyl*	29. Compositae ***Sonchus oleraceus*** *hodeid, hawwa, khuwaysh*	32. Convolvulaceae ***Convolvulus vergatus*** *faaghi, rukham, bia'd*	59. Resedaceae ***Reseda aucheri*** *zinban*	62. Rubiaceae ***Jaubert ia aucheri*** *khurman*
1. Acanthaceae ***Barleria hochstetteri*** *thefied*	30. Convolvulaceae ***Convolvulus pilosellifolius*** *hibab risha*	31. Convolvulaceae ***Convolvulus prostatus*** *hathma*	60. Resedaceae ***Reseda muricata*** *zinban*	61. Rhamnaceae ***Sagetaria spiciflora*** *Nimth*

Table 2(c). Layout of tree species in field genebank of pasture plants of Oman in three columns each containing 15 plant species

TREES

XI	XII	XIII
15. Mimosaceae ***Acacia gerardi*** *tulh*	16. Mimosaceae ***Acacia laeta*** *Temrit*	
14. Mimosaceae ***Acacia etbaica*** *samra*	17. Mimosaceae ***Acacia nilotica (arabica)*** *Qarat*	
13. Mimosaceae ***Acacia ehrenbergiana*** *salam*	18. Mimosaceae ***Acacia senegal*** *thor*	
12. Fabaceae ***Tamarindus indica*** *sabbar, areyr, tumar hindi*	19. Mimosaceae ***Acacia tortilis*** *Samar*	
11. Fabaceae ***Ceratonia oreothauma sub sporeothauma*** *tiyu*	20. Mimosaceae ***Pithecellobium dulce*** *gaaf al bahr, kuzooh*	
10. Coniferophyta ***Juniperus excelsa*** *al alan*	21. Mimosaceae ***Prosopis cineraria*** *gaaf*	
9. Compositae ***Blepharispermum hirtum*** *xfot*	22. Moraceae ***Ficus cordata sub sp. salicifolia*** *lithab*	
8. Combretaceae ***Anogeissus dhofarica*** *misteh, Meset*	23. Moraceae ***Ficus lutea*** *derfit, zerfit*	38. Verbenaceae ***Avicennia marina*** *qurm*
7. Celastraceae ***Maytenus senegalensis*** *	24. Moraceae ***Ficus palmata*** *siqab, thiqab*	37. Tamaricaceae ***Tamarix aphylla*** *athal, tarfa*
6. Capparaceae ***Maerua crassifolia*** *sarh*	25. Moraceae ***Ficus sycomorus*** *geydeh, gizit*	36. Solnaceae ***Lycium shawii*** *qasad*
5. Capparaceae ***Boscia arabica*** *sir*	26. Moraceae ***Ficus vasta*** *teyk, tik*	35. Sapotaceae ***Monotheca buxifolia*** *but*
4. Caesalpiniaceae ***Delonix elata*** *erer, erir*	27. Moringaceae ***Moringa peregrina*** *shua'*	34. Sapindaceae ***Allophylus rubifolius*** *zerkim*
3. Anacardaceae ***Rhus aucheri*** *Qataf*	28. Oleaceae ***Olea europaea*** *itm*	33. Rhamnaceae ***Ziziphus spina-christi*** *cider, nabaq, nabaz*
2. Agavaceae ***Dracaena serrulata*** *ariyeb, ayrob*	29. Rhamnaceae ***Rhamnus studdo*** *hagor mitayn*	32. Rhamnaceae ***Ziziphus Mauritania (Jujube)*** *cider, nabaq*
1. Acanthaceae ***Blepharis dhofarensis*** *alib, alyib, ilob, ayzob*	30. Rhamnaceae ***Sagetaria spiciflora*** *nimth*	31. Rhamnaceae ***Ziziphus leucodermis*** *cider, nabaq, nabaz*

Table 2(d). Layout of monocotyledonous species in field genebank of pasture plants of Oman in a column containing 15 plant species

GRASSES
XIV
62. Asphodelus fistulosus var. tenuifolius
61. Juncus rigidus
60. Themeda quadrivalis
59. Stipagrostis raddiana
58. Stipagrostis plumosa
57. Stipagrostis ciliata
56. Sporobolous virginicus
55. Sporobolus spicatus
54. Sporobolus nervosus
53. Sporobolus ioclades
52. Sporobolus arabicus
51. Setaria viridis
50. Setaria verticillata
49. Setaria pumila
48. Setaria intermedia
47. Polypogon monospeliensis
46. Phragmites australis
45. Pennisetum setaceum
44. Pennisetum orientale
43. Pennisetum divisum
42. Panicum turgidum
41. Panicum trichoides
40. Panicum maximum
39. Panicum coloratum
38. Panicum atrosanguineum
37. Panicum antidotale
36. Ochthochola compressa- Annual
35. Loudetia flavida
34. Lolium rigidum
33. Lasiurus hirsutus

32. Halopyrum mucronatum
31. Eragrostis ciliaris
30. Eragrostis cilianensis
29. Eragrostis barrelieri
28. Eleusine indica
27. Echinochloa colona
26. Digitaria sanguinalis
25. Dichanthium micranthum
24. Dichanthium faveolatum
23. Dichanthium aristatum
22. Dichanthium annulatum
21. Dactyloctenuim scindicum
20. Dactyloctenuim aegyptium
19. Cynodon dactylon
18. Cymbopogon schoenanthus
17.Cutandia memphitica
16. Coelacyrum piercei
15. Chloris virgata
14. Chloris plumosus
13. Centropodia forssakli
12. Cenchrus setigerus
11. Cenchrus pennisetiformis
10. Cenchrus ciliaris
9. Brachiaria erusiformis
8. Avena barbata
7. Arthraxon lancifoilus
6. Aristida mutabilis
5. Aristida adscensions
4. Apluda mutica
3. Aeluropus lagopoides
2. Cyperus rotundus
1. Cyperus conglomeratus

Bulk and Basic Seed Multiplication of Indigenous Forage Species (UNDER APRP-Phase-II 2.3.2)

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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 for a period of one year between 2003 and 2004. Total seed yields collected through four harvests were 9.820 kg, 2.420 kg and 0.390 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 Jabel 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 ciliaris (UAE accession) and *Coelachyrum piercei* (UAE accession) during 1999-2002 at Sohar Research Station. Hence, it was 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 during April 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 P_2O_5 and 150 kg K_2O 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 third and fourth harvests were taken subsequently. 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 husked seed yield harvested (collected) have been recorded after cleaning the produce.

Table 1. Values 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 (1:5) dS	5.70
PH (1:5)	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 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 9.820 kg of bulk seed was collected in four harvests while in case of *Cenchrus ciliaris* (Rumais) basic seed collected was 2.42 kg. A very little basic seed of about 0.390 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 0-6 % was observed in each species in the initial germination test carried out using husked seed immediately after harvest while it was between 19 and 32 % after four months. This indicated presence of dormancy in the seeds.

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 (2003-2004)

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							
1. *C. ciliaris* (UAE)	90	85	32	78	3.140	0-5%	26%
2. *C. ciliaris* (Rumais)	65	60	27	72	0.825	0-5%	22%
3. *L. hirsutus* (Rumais)	72	70	37	70	0.175	0-2%	21%
II- Harvest							
1. *C. ciliaris* (UAE)	-	80	35	80	2.710	0-5%	32%
2. *C. ciliaris* (Rumais)	-	58	32	70	0.415	0-3%	28%
3. *L. hirsutus* (Rumais)	-	68	38	71	0.075	0-2%	27%
III- Harvest							
1. *C. ciliaris* (UAE)	-	79	30	75	1.650	0-4%	28%
2. *C. ciliaris* (Rumais)	-	55	30	68	0.515	0-3%	24%
3. *L. hirsutus* (Rumais)	-	65	35	75	0.055	0-3%	23%
IV- Harvest							
1. *C. ciliaris* (UAE)	-	75	32	76	2.320	0-6%	26%
2. *C. ciliaris* (Rumais)	-	55	28	65	0.665	0-4%	27%
3. *L. hirsutus* (Rumais)	-	62	42	76	0.085	0-3%	19%
Total Seed Yield (kg)							
1. *C. ciliaris* (UAE)	-	-	-	-	9.820	-	-
2. *C. ciliaris* (Rumais)	-	-	-	-	2.420	-	-
3. *L. hirsutus* (Rumais)	-	-	-	-	0.390	-	-

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

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Abstract

Two indigenous rangeland forage species viz. *Cenchrus ciliaris L.* (UAE) and *Coelachyrum piercei L.*(UAE) collected under ICARDA- APRP Phase- I were investigated under ICARDA-APRP Phase-II from April-May 2001 to October-November 2003 spanning nine harvests, for their response to varying 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. 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 nine harvests) (474.58 kg/ha under 100 cm and 405.61 kg/ha under 50 cm row spacing) followed by *Cenchrus ciliaris* (442.76 kg/ha under 100 cm and 384.02 kg/ha under 50 cm row spacing) and *Coelachyrum piercei* (240.65 kg/ha under 100 cm and 198.59 kg/ha under 50 cm row spacing). All the three grasses showed very low germination % when tested immediately (1-2 weeks) after harvest not only for bulk seed (0 to 1.5%) but also for selected seed (0.8% to 2.8%). Mean germination % of grass species recorded after 12 months of harvests was significantly greater (52.62%) than that recorded after 5 months (33.67%) of harvests. Of the three grass species, *Cenchrus ciliaris* recorded significantly ($p<0.01$) highest germination % (49.68 %) followed by *Chloris gayana* (41.05%) and *Coelachyrum piercei* (38.71%). Selected seed had significantly ($p<0.01$) higher germination % (53.21%) than bulk seed (33.08%).

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. Rangeland grass species appear to have been neglected material for investigation especially on agronomic aspects of seed production as very few references have been available so far (Chatterjee and Das, 1989 and Boonman, 1972). It is known fact that as grass species have been evolved as perennials for vegetative forage yield they are shy yielders with very low seed productivity. As such, the productivity and availability of seeds in the panicle *per se* at harvest have been observed to be important factors in the seed production of any grass species (Chatterjee and Das, 1989: Loch and Clark, 2000). In 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. Hence, investigations have been conducted from April-May 2001 to October - November 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.

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 P_2O_5 and 150 kg K_2O 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. Nine seed harvests were taken up during the period of experimentation.

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N (%)	0.04
Av.P (meq./100g)	15.76

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 bulk seed and selected seed samples of each harvest were tested for germination using Top of Paper (TP) method with five replications (Agrawal, 1980) not only at harvest but also after five and twelve months of each harvest. The data on germination were subjected to ANOVA considering harvests, seed type, time of test and grass species as factors.

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. Only the significant interactions involving grass species with other factors have been discussed (Tables 2 to 7).

Plant stand (%):

In respect of plant stand, main effects of all factors and effects of 2- factor interactions viz. harvest x inter-row spacing, harvest x inter-plant spacing, harvest x grass species, inter-row spacing x grass species and inter-plant spacing x grass species, and that of one 3- factor interaction such as harvest x inter-row spacing x grass species were highly significant ($p<0.01$) (Table 2) indicating differential expression of grass species for persistence of plant stand in subsequent harvests under varying inter-row and inter-plant spacing. Among the grass species studied, *Chloris gayana* and *Cenchrus ciliaris* had shown highest ability of persistency during period of experimentation. *Chloris gayana* had significantly (($p < 0.05$) highest persistency to the extent of 91.10% and 92.20 % as compared to *Cenchrus ciliaris* (86.40 % and 89.70 %) and *Coelachyrum piercei* (46.10 % and 36.70 %) recorded at last harvest respectively under inter-row spacing of 50 cm and 100 cm. In general, plant stand persistency of all grass species was of higher order under inter-row spacing of 100 cm. Plant stand of *Chloris gayana* was stable from first (96.70%) to eighth harvest (97.20%) which was significantly ($p <0.05$) reduced at last harvest (92.20%) under inter-row spacing of 100 cm. However, under inter-row spacing of 50 cm, plant stand of *Chloris gayana* was stable from first to sixth harvest (97.20%) which was significantly ($p <0.05$) reduced at seventh harvest (93.60%). There was no significant reduction further till last harvest (91.11%). There was no significant reduction further till last harvest (91.11%). Plant stand of *Cenchrus ciliaris* was stable from first (93.90%) to sixth harvest (90.90%) which was significantly ($p <0.05$) reduced at seventh harvest (90.40%) which however, remained stable till last harvest (89.70%) under inter-row spacing of 100 cm. On the other hand, under inter-row spacing of 50 cm plant stand of *Cenchrus ciliaris* was stable from first (96.60%) to second harvest (93.70%) which was significantly ($p <0.05$) and gradually reduced to 88.60% at seventh harvest. There was no significant reduction further till last harvest (86.40%). The plant stand of *Coelachyrum piercei* got gradually and significantly deteriorated in subsequent cuts from first harvest in all the plots of different inter-row and interplant spacings. The mean plant stands of *Coelachyrum piercei* were reduced to 36.70% and 46.10% at last harvest from initial plant stands of 95.50% 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 had comparatively higher plant stand than narrow inter-row or inter-plant spacings (Table 2).

Plant Height:

In respect of plant height, main effects of all factors, effects of 2- factor interactions viz. harvest x inter-row spacing, harvest x inter-plant spacing, harvest x grass species and inter-row spacing x grass species, effects of two 3- factor interactions such as harvest x inter-row spacing x grass species and inter-row spacing x inter-plant spacing x grass species and also effect of four factor interaction were significant to highly significant ($p<0.05$) (Table 2) indicating differential expression of grass species in respect of plant height in different harvests under varying inter-row and inter-plant spacing. (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 values of over-all means of plant height suggest that Cenchrus ciliaris and Coelachyrum piercei were significantly ($p<0.05$) taller at 100-cm inter-row spacing (114.54 and 72.15 cm) than at 50 cm inter-row spacing (110.51 and 63.63 cm). However, varying inter-row spacing did not influence the performance of Chloris gayana in respect of plant height (104.16 cm at 100-cm inter-row spacing and 103.60 cm at 100 cm inter-row spacing (Table 3).

Number of tillers / plant:

In respect of number of tillers, main effects of all factors and their interactions except the effects of one 2- factor interaction viz. harvests x inter-plant spacing and one 3-factor interaction viz. harvest x inter-plant spacing x grass species and that of 4-factor interaction were significant to 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 significantly ($p<0.05$) higher number of tillers than Coelachyrum piercei, which recorded lower number of tillers in the later harvests. Cenchrus ciliaris had produced significantly ($p<0.05$) higher number of tillers ranging from 97.49 to 128.74 at 100 cm row spacing than those at 50 cm row-spacing (94.97 to 114.83) in different harvests. Similarly, Chloris gayana had also significantly ($p<0.05$) higher number of tillers ranging from 53.71 to 142.01 at 100 cm row spacing than those at 50 cm row-spacing (51.92 to 114.73) in different harvests. Conversely, in case of Coelachyrum piercei except in the first two harvests, in all subsequent harvests it produced significantly ($p<0.05$) less number of tillers ($p<0.05$) in comparison with other two grass species. The mean number of tillers at 100 row-spacing (79.28 to 123.88) was significantly ($p<0.05$) higher ($p< 0.05$) than that at 50-cm row spacing (77.35 to 105.71) in at least seven harvests. The mean number of tillers at 100-cm plant spacing was significantly ($p<0.05$) 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 four 2- factor interactions viz. inter-row spacing x inter-plant spacing, harvests x grass species, Inter-row spacing x grass species and inter-plant spacing x grass species and also effects of two 3-factor interactions such as harvest x inter-row spacing x grass species and inter-row spacing x inter-plant spacing x grass species were significant to highly significant ($p<0.05$) (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 produced significantly higher number of panicles ranging from 71.20 to 93.22 at 100 cm row-spacing than those at 50 cm row-spacing (65.72 to 80.61) 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 than those at 50 cm row-spacing (57.41 to 79.18) 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 least 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 seven different harvests. The mean number of panicles at 100-cm plant spacing was significantly ($p<0.05$) 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 578.05 and 240.78 to 734.61 kg/ha at 50 and 100 cm row spacings, respectively) produced significantly ($p<0.05$) 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 (104.45 to 282.75 and 128.89 to 340.53 kg/ha at 50 and 100 cm row spacings, respectively (Table 6). The mean grass seed yield irrespective of species was significantly ($p<0.05$) higher in the fifth (404.19 kg/ha at 50 cm row spacing and 458.64 kg at 100 cm row spacing) and sixth (412.74 kg/ha at 50 cm row spacing and 501.02 kg at 100 cm row spacing) harvests than the preceding and succeeding harvests. In almost all the harvests, 100 cm row spacing gave significantly higher yield than 50 cm row spacing. Interestingly, there was no significant difference ($p>0.05$) between the seed yields of three inter-plant spacings in most of the harvests under both inter-row spacings. Only in fourth harvest, wider inter-plant spacing (100 cm) was significantly ($p<0.05$) higher than narrow inter-plant spacing (25 cm) under inter-row spacing of 50 cm. On the other hand, under 100 cm inter-row spacing, in two harvests (first and fifth), narrow inter-plant spacing (25 cm) significantly ($p<0.05$) out-yielded wider inter-plant spacing (100 cm) while in other two harvests (second and sixth), wider inter-plant spacing (100 cm) significantly ($p<0.05$) produced more seed yield than narrow inter-plant spacing (25 cm). Among the grass species at 50 cm row spacing irrespective of interplant spacings, *Chloris gayana* produced significantly higher yield in at least two harvests (second and sixth) taken mostly from the winter growth period (408.78 to 578.05 kg/ha, $p<0.05$) and in one harvest (fifth) taken from summer growth period (524.89 kg/ha, $p<0.05$) than *Cenchrus ciliaris* while *Cenchrus ciliaris* out-yielded significantly *Chloris gayana* with 306.11 kg/ha ($p<0.05$) only in the first harvest taken from summer growth period. Similarly at 100 cm inter-row spacing, *Chloris gayana* produced significantly higher yield in three harvests (second, sixth and seventh) taken from winter growth period (507.00 to 734.61 kg/ha, $p<0.05$) and in two harvests (eighth and ninth) taken from summer growth period (463.33 to 517.66 kg/ha, $p<0.05$) than *Cenchrus ciliaris* while *Cenchrus ciliaris* out-yielded *Chloris gayana* in two harvests (first and fifth) (493.33 to 550.49 kg/ha, $p<0.05$) taken only from summer growth period (Table 6).

Germination %:

Table 7 shows germination % of bulk and selected seed samples of three grass species recorded after about five and twelve months of nine harvests. The results indicated that main effects all the factors viz. harvests, seed type, time of test and grass species, effects of 2-factor interactions such as harvests x time of test, harvest x grass species and time of test x grass species and a 3-factor interaction viz. harvests x time of test x grass species, were highly significant ($p<0.01$). All the three grasses showed very low germination % when tested immediately (1-2 weeks) after harvest not only for bulk seed (0 to 1.5%) but also for selected seed (0.8% to 2.8%). However, germination % was seen gradually improved further on storage at room temperature. This is evidenced by the fact that mean germination % of grass species recorded after 12 months of harvests was significantly ($p<0.01$) greater (52.62%) than that recorded after 5 months (33.67%) of harvests. This clearly indicates that dormancy exists in freshly harvested grass seed, which gets broken down gradually depending up on longevity of storage of seed. Of the three grass species, Cenchrus ciliaris recorded significantly ($p<0.01$) highest germination % (49.68 %) followed by Chloris gayana (41.05%) and Coelachyrum piercei (38.71%). Selected seed had significantly ($p<0.01$) higher germination % (53.21%) than bulk seed (33.08%) (Table 7). Lower germination % in bulk seed could be 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 results of the present investigation up to nine 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 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 nine harvests) (474.58 kg/ha under 100 cm and 405.61 kg/ha under 50 cm row spacing) followed by Cenchrus ciliaris (442.76 kg/ha under 100 cm and 384.02 kg/ha under 50 cm row spacing) and Coelachyrum piercei (240.65 kg/ha under 100 cm and 198.59 kg/ha under 50 cm row spacing). All the three grasses showed very low germination % when tested immediately (1-2 weeks) after harvest not only for bulk seed (0 to 1.5%) but also for selected seed (0.8% to 2.8%). Mean germination % of grass species recorded after 12 months of harvests was significantly greater (52.62%) than that recorded after 5 months (33.67%) of harvests. Of the three grass species, Cenchrus ciliaris recorded significantly ($p<0.01$) highest germination % (49.68 %) followed by Chloris gayana (41.05%) and Coelachyrum piercei (38.71%). Selected seed had significantly ($p<0.01$) higher germination % (53.21%) than bulk seed (33.08%).

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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 nine 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	9.47	9.50	9.83	9.60	9.33	9.50	9.67	9.50
	50 cm	9.67	9.33	9.50	9.50	9.33	8.83	9.50	9.22
	100 cm	9.83	9.83	9.83	9.83	9.5	9.83	9.83	9.72
	Mean (grass species)	9.66	9.55	9.72		9.39	9.39	9.67	
	Row Mean		9.64				9.48		
2 Jan-Feb 02	25 cm	9.33	8.57	9.83	9.24	9.33	9.17	9.67	9.39
	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	9.5	9.33	9.83	9.55
	Mean (grass species)	9.37	8.82	9.72		9.39	9.00	9.67	
	Row Mean		9.3				9.35		
3 Apr-May 02	25 cm	9.33	8.50	9.83	9.22	9.33	9.17	9.67	9.39
	50 cm	9.17	8.50	9.50	9.06	9.33	8.50	9.50	9.11
	100 cm	9.42	9.33	9.83	9.53	9.5	9.33	9.83	9.55
	Mean (grass species)	9.31	8.78	9.72		9.39	9.00	9.67	
	Row Mean		9.27				9.35		
4 Jul-Aug 02	25 cm	9.17	8.17	9.83	9.06	9.33	8.73	9.67	9.24
	50 cm	9.17	8.33	9.50	9.00	9.17	8.17	9.5	8.95
	100 cm	9.42	9.00	9.83	9.42	9.25	8.83	9.83	9.3
	Mean (grass species)	9.25	8.50	9.72		9.25	8.58	9.67	
	Row Mean		9.16				9.16		
5 Oct-Nov 02	25 cm	9.03	6.17	9.83	8.34	9.25	8.00	9.67	8.97
	50 cm	9.00	6.33	9.50	8.28	9.08	7.27	9.50	8.62
	100 cm	9.17	7.00	9.83	8.67	9.13	8.17	9.83	9.04
	Mean (grass species)	9.07	6.50	9.72		9.15	7.81	9.67	
	Row Mean		8.43				8.88		
6 Jan-Feb 03	25 cm	9.00	5.50	9.83	8.11	9.17	6.67	9.67	8.50
	50 cm	8.92	5.33	9.50	7.92	9.00	7.00	9.50	8.50
	100 cm	9.17	6.00	9.83	8.33	9.1	7.67	9.83	8.87
	Mean (grass species)	9.03	5.61	9.72		9.09	7.11	9.67	
	Row Mean		8.12				8.62		
7 Apr-May 03	25 cm	8.90	5.00	9.42	7.77	9.13	5.83	9.50	8.16
	50 cm	8.83	5.17	9.25	7.75	9.00	6.33	9.38	8.24
	100 cm	8.83	5.33	9.42	7.86	9.00	7.10	9.50	8.53
	Mean (grass species)	8.86	5.17	9.36		9.04	6.42	9.46	
	Row Mean		7.79				8.31		
8 Jul-Aug 03	25 cm	8.90	4.77	9.42	7.69	8.98	5.63	9.50	8.04
	50 cm	8.80	4.90	9.25	7.70	9.00	6.13	9.38	8.17
	100 cm	8.75	5.13	9.42	7.77	9.00	6.63	9.50	8.38
	Mean (grass species)	8.82	4.93	9.36		8.99	6.13	9.46	
	Row Mean		7.70				8.20		
9 Oct-Nov 03	25 cm	8.67	3.33	9.17	7.06	8.91	4.00	9.25	7.39
	50 cm	8.58	3.67	9.00	7.08	9.00	4.33	9.17	7.50
	100 cm	8.67	4.00	9.17	4.39	9.00	5.50	9.25	7.92
	Mean (grass species)	8.64	3.67	9.11		8.97	4.61	9.22	

Row Mean	7.14				7.6			
Mean (grass species) over harvests and inter-plant spacing	8.76	6.80	9.57		9.18	7.56	9.57	
Mean inter-plant spacing over harvests								
25 cm	9.09	6.61	9.67		9.20	7.41	9.59	
50 cm	8.94	6.09	9.39		9.14	7.23	9.44	
100 cm	9.21	7.22	9.67		9.22	8.04	9.69	

Statistical Parameters:

	F-Test	**LSD (5%)**
Harvest	**	0.12
Inter-row spacing	**	0.06
Harvest x Inter-row spacing	**	0.17
Inter-plant spacing	**	0.07
Harvest x Inter-plant spacing	**	0.21
Inter-row spacing x Inter-plant spacing	NS	-
Harvest x Inter-row spacing x Inter-plant spacing	NS	-
Grass species	**	0.07
Harvest x Grass species	**	0.21
Inter-row spacing x Grass species	**	0.10
Harvest x Inter-row spacing x Grass species	**	0.30
Inter-plant spacing x Grass species	**	0.12
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 (%)	3.81	

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 nine 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			
9 Oct-Nov 03	25 cm	106.33	56.33	100.00	87.56	117.67	66.67	87.67	90.67
	50 cm	111.67	54.00	92.00	85.89	102.00	61.67	98.33	87.33
	100 cm	96.67	52.33	96.00	81.67	100.00	63.67	95.67	86.44
	Mean (grass species)	104.89	54.22	96.00		106.56	64.00	93.89	
	Row Mean		85.04				88.15		
Mean (grass species) over harvests and inter-plant spacing		110.51	63.63	103.06		114.54	72.15	104.16	
Mean inter-plant spacing over harvests									
25 cm		104.93	63.78	102.65		115.48	71.98	99.02	
50 cm		112.76	62.60	101.97		112.62	71.74	106.74	
100 cm		113.84	64.49	104.56		115.50	72.72	106.73	

Statistical Parameters:

	F-Test	**LSD (5%)**
Harvest	**	2.76
Inter-row spacing	**	1.30
Harvest x Inter-row spacing	**	3.91
Inter-plant spacing	*	1.59
Harvest x Inter-plant spacing	**	4.79
Inter-row spacing x Inter-plant spacing	NS	-
Harvest x Inter-row spacing x Inter-plant spacing	NS	-
Grass species	**	1.59
Harvest x Grass species	**	4.79
Inter-row spacing x Grass species	**	2.26
Harvest x Inter-row spacing x Grass species	NS	-
Inter-plant spacing x Grass species	NS	-
Harvest x Inter-plant spacing x Grass species	**	8.29
Inter-row spacing x Inter-plant spacing x grass species	**	3.91
Harvest x Inter-row spacing x Inter-plant spacing x grass species	**	11.73
CV (%)	7.76	

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 nine 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		
9 Oct-Nov 03	25 cm	108.33	53.33	81.67	81.11	73.33	63.67	96.00	77.67
	50 cm	85.00	52.33	78.33	71.89	89.33	63.00	108.33	86.89
	100 cm	88.33	59.00	85.00	77.44	112.33	67.67	119.00	99.67
	Mean (grass species)	93.89	54.89	81.67		91.67	64.78	107.78	
	Row Mean		76.81				88.07		
Mean (grass species) over harvests and inter-plant spacing		101.38	76.70	88.21		111.66	85.74	109.50	
Mean inter-plant spacing over harvests									
25 cm		109.22	75.18	85.41		99.36	83.67	103.83	
50 cm		96.12	78.61	83.53		109.42	85.57	109.36	
100 cm		98.80	76.32	95.70		126.21	87.98	115.32	

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	5.15
Inter-row spacing	**	2.43
Harvest x Inter-row spacing	**	7.28
Inter-plant spacing	**	2.97
Harvest x Inter-plant spacing	NS	-
Inter-row spacing x Inter-plant spacing	**	4.20
Harvest x Inter-row spacing x Inter-plant spacing	*	12.61
Grass species	**	2.97
Harvest x Grass species	**	8.92
Inter-row spacing x Grass species	**	4.20
Harvest x Inter-row spacing x Grass species	*	12.61
Inter-plant spacing x Grass species	*	5.15
Harvest x Inter-plant spacing x Grass species	NS	-
Inter-row spacing x Inter-plant spacing x grass species	**	7.28
Harvest x Inter-row spacing x Inter-plant spacing x grass species	NS	-
CV (%)		14.29

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 nine 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			
	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)
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	
9 Oct-Nov 03	Row Mean	63.07				78.33			
	25 cm	63.00	24.33	56.33	47.89	57.67	43.33	79.00	60.00
	50 cm	51.67	32.00	61.33	48.33	75.33	50.33	79.33	68.33

	100 cm	53.67	33.33	70.00	52.33	85.00	52.67	84.33	74.00
	Mean (grass species)	56.11	29.89	62.56		72.67	48.78	80.89	
	Row Mean		49.52				67.44		
Mean (grass species) over harvests and inter-plant spacing		61.07	48.31	65.60		76.02	64.94	77.56	
Mean inter-plant spacing over harvests									
25 cm		62.74	42.93	63.09		67.53	57.45	73.10	
50 cm		57.02	51.74	63.87		70.56	67.48	76.90	
100 cm		63.47	50.26	69.84		89.96	69.89	82.67	

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	3.30
Inter-row spacing	**	1.56
Harvest x Inter-row spacing	NS	-
Inter-plant spacing	**	1.91
Harvest x Inter-plant spacing	NS	-
Inter-row spacing x Inter-plant spacing	**	2.70
Harvest x Inter-row spacing x Inter-plant spacing	NS	-
Grass species	**	1.91
Harvest x Grass species	**	5.72
Inter-row spacing x Grass species	*	2.70
Harvest x Inter-row spacing x Grass species	**	8.09
Inter-plant spacing x Grass species	**	3.30
Harvest x Inter-plant spacing x Grass species	NS	-
Inter-row spacing x Inter-plant spacing x grass species	*	4.67
Harvest x Inter-row spacing x Inter-plant spacing x grass species	NS	-
CV (%)	13.35	

Table 6. Means of seed yield (with husk) (kg/ha) of two indigenous rangeland forage grass species and Rhodes grass under two inter-row and three-interplant spacing in nine 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	351.00	173.33	180.00	234.78	790.00	260.67	275.00	441.89
	50 cm	356.00	190.33	216.67	254.33	344.67	396.33	243.33	328.11
	100 cm	211.33	233.00	260.33	234.89	345.33	350.00	204.01	299.78
	Mean (grass species)	306.11	198.89	219.00		493.33	335.67	240.78	
	Row Mean		241.33				356.59		
2 Jan-Feb 02	25 cm	350.50	259.84	380.50	330.28	338.16	270.83	492.16	367.05
	50 cm	290.00	308.16	394.66	330.94	330.50	273.16	509.33	371.00
	100 cm	313.80	263.16	451.16	342.72	426.00	354.83	519.50	433.44
	Mean (grass species)	318.10	277.05	408.78		364.89	299.61	507.00	
	Row Mean		334.65				390.50		
3 Apr-May 02	25 cm	339.16	232.66	313.50	295.11	326.16	213.16	376.50	305.28
	50 cm	337.16	238.16	352.33	309.22	365.16	250.00	388.83	334.66
	100 cm	351.83	238.00	384.16	324.66	385.66	274.16	426.16	362.00
	Mean (grass species)	342.72	236.28	350.00		359.00	245.78	397.16	
	Row Mean		309.67				333.98		
4 Jul-Aug 02	25 cm	343.50	195.66	322.83	287.33	353.50	218.83	309.66	294.00
	50 cm	362.16	223.83	370.00	318.66	379.66	228.50	310.66	306.28
	100 cm	397.16	249.83	380.00	342.33	420.00	261.83	345.50	342.44
	Mean (grass species)	367.61	223.11	357.61		384.39	236.39	321.94	
	Row Mean		316.11				314.24		
5 Oct-Nov 02	25 cm	441.67	256.00	460.53	386.07	779.73	309.60	482.40	523.91
	50 cm	445.07	284.53	545.07	424.89	435.47	333.07	457.07	408.54
	100 cm	328.00	307.73	569.07	401.60	436.27	378.93	515.20	443.47
	Mean (grass species)	404.91	282.75	524.89		550.49	340.53	484.89	
	Row Mean		404.19				458.64		
6 Jan-Feb 03	25 cm	517.30	174.77	546.70	412.92	510.53	222.83	716.57	483.31
	50 cm	421.17	195.30	540.87	385.78	463.63	213.97	740.37	472.66
	100 cm	465.50	206.50	646.57	439.52	613.20	281.17	746.90	547.09
	Mean (grass species)	467.99	192.19	578.05		529.12	239.32	734.61	
	Row Mean		412.74				501.02		
7 Apr-May 03	25 cm	457.40	129.00	454.80	347.07	457.00	163.00	586.00	402.00
	50 cm	453.80	149.40	431.60	344.93	492.20	157.40	605.80	418.47
	100 cm	505.80	152.60	517.40	391.93	533.20	215.40	619.80	456.13
	Mean (grass species)	472.33	143.67	467.93		494.13	178.60	603.87	
	Row Mean		361.31				425.53		
8 Jul-Aug 03	25 cm	385.00	120.00	398.17	301.06	400.00	142.50	501.33	347.94
	50 cm	390.00	132.50	365.33	295.94	406.67	147.83	518.33	357.61
	100 cm	421.67	134.17	445.83	333.89	458.33	192.83	533.33	394.83
	Mean (grass species)	398.89	128.89	403.11		421.67	161.05	517.66	
	Row Mean		310.30				366.79		
9 Oct-Nov 03	25 cm	374.07	101.67	323.33	266.35	365.80	108.33	448.33	307.49
	50 cm	359.60	105.00	310.00	258.20	369.93	125.00	461.67	318.87
	100 cm	398.87	106.67	390.00	298.51	427.80	153.33	480.00	353.71

	Mean (grass species)	377.51	104.45	341.11		387.84	128.89	463.33	
	Row Mean		274.36				326.69		
Mean (grass species) over harvests and inter-plant spacing		384.02	198.59	405.61		442.76	240.65	474.58	
Mean inter-plant spacing over harvests									
25 cm		395.51	182.55	375.60		480.10	212.19	465.33	
50 cm		379.44	203.02	391.84		398.65	236.14	470.60	
100 cm		377.11	210.18	449.39		449.53	273.61	487.82	

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	24.17
Inter-row spacing	**	11.40
Harvest x Inter-row spacing	**	34.19
Inter-plant spacing	**	13.96
Harvest x Inter-plant spacing	**	41.87
Inter-row spacing x Inter-plant spacing	NS	-
Harvest x Inter-row spacing x Inter-plant spacing	**	59.21
Grass species	**	13.96
Harvest x Grass species	**	41.87
Inter-row spacing x Grass species	NS	-
Harvest x Inter-row spacing x Grass species	**	59.21
Inter-plant spacing x Grass species	**	24.17
Harvest x Inter-plant spacing x Grass species	**	72.52
Inter-row spacing x Inter-plant spacing x grass species	**	34.19
Harvest x Inter-row spacing x Inter-plant spacing x grass species	**	102.56
CV (%)	13.68	

Table 7. Mean germination % of bulk and selected seed samples of three grass species recorded after five and twelve months of nine harvests

Harvests	Time of Test (After)	*Cenchrus ciliaris* Bulk seed	*Cenchrus ciliaris* Selected seed	*Cenchrus ciliaris* Mean	*Coelachyrum piercei* Bulk seed	*Coelachyrum piercei* Selected seed	*Coelachyrum piercei* Mean	*Chloris gayana* Bulk seed	*Chloris gayana* Selected seed	*Chloris gayana* Mean	Mean over grass species Bulk seed	Mean over grass species Selected seed	Mean over grass species Mean
I	5 m	28.20	48.10	38.15	25.20	45.30	35.25	18.35	38.15	28.25	23.92	43.85	
Sept. 01	12 m	58.27	78.27	68.27	43.27	63.27	53.27	37.37	57.37	47.37	46.30	66.30	
	Mean	**43.24**	**63.19**	**53.21**	**34.24**	**54.29**	**44.26**	**27.86**	**47.76**	**37.81**	**35.11**	**55.08**	**45.10**
II	5 m	26.25	46.25	36.25	23.56	43.56	33.56	22.75	42.75	32.75	24.19	44.19	
Jan.-Feb. 02	12 m	49.35	69.35	59.35	34.33	54.33	44.33	48.66	68.66	58.66	44.11	64.11	
	Mean	**37.80**	**57.80**	**47.80**	**28.95**	**48.95**	**38.95**	**35.71**	**55.71**	**45.71**	**34.15**	**54.15**	**44.15**
III	5 m	31.21	51.11	41.16	26.32	46.15	36.24	21.35	41.33	31.34	26.29	46.20	
Apr.-May 02	12 m	50.38	70.38	60.38	31.67	51.67	41.67	49.33	69.33	59.33	43.79	63.79	
	Mean	**40.80**	**60.75**	**50.77**	**29.00**	**48.91**	**38.95**	**35.34**	**55.33**	**45.34**	**35.04**	**55.00**	**45.02**
IV	5 m	27.25	47.13	37.19	19.35	39.22	29.29	17.36	37.31	27.34	21.32	41.22	
Jul.-Aug.02	12 m	61.32	81.32	71.32	28.13	48.13	38.13	40.67	60.67	50.67	43.37	63.37	
	Mean	**44.29**	**64.23**	**54.26**	**23.74**	**43.68**	**33.71**	**29.02**	**48.99**	**39.00**	**32.35**	**52.30**	**42.33**
V	5 m	26.75	46.33	36.54	24.36	44.15	34.26	19.25	39.27	29.26	23.45	43.25	
Oct.-Nov.02	12 m	52.67	72.67	62.67	39.19	59.19	49.19	38.33	58.33	48.33	43.40	63.40	
	Mean	**39.71**	**59.50**	**49.61**	**31.78**	**51.67**	**41.72**	**28.79**	**48.80**	**38.80**	**33.43**	**53.32**	**43.38**
VI	5 m	29.05	49.20	39.13	22.58	42.41	32.50	22.55	42.15	32.35	24.73	44.59	
Jan.-Feb.03	12 m	48.32	68.32	58.32	35.13	55.13	45.13	43.79	63.79	53.79	42.41	62.41	
	Mean	**38.69**	**58.76**	**48.72**	**28.86**	**48.77**	**38.81**	**33.17**	**52.97**	**43.07**	**33.57**	**53.50**	**43.54**
VII	5 m	28.75	48.53	38.64	24.62	44.15	34.39	20.36	40.33	30.35	24.58	44.34	
Apr.-May 03	12 m	37.93	67.93	52.93	28.33	48.33	38.33	39.33	59.33	49.33	35.20	58.53	
	Mean	**33.34**	**58.23**	**45.79**	**26.48**	**46.24**	**36.36**	**29.85**	**49.83**	**39.84**	**29.89**	**51.43**	**40.66**
VIII	5 m	24.26	44.15	34.21	18.79	38.24	28.52	19.33	39.46	29.40	20.79	40.62	
Jul.-Aug.03	12 m	52.68	72.68	62.68	27.17	47.17	37.17	37.69	57.69	47.69	39.18	59.18	
	Mean	**38.47**	**58.42**	**48.44**	**22.98**	**42.71**	**32.84**	**28.51**	**48.58**	**38.54**	**29.99**	**49.90**	**39.95**
IX	5 m	27.02	47.08	37.05	23.99	43.63	33.81	22.03	42.14	32.09	24.35	44.28	
Oct.-Nov.03	12 m	49.98	69.98	59.98	41.79	61.79	51.79	40.67	60.67	50.67	44.15	64.15	
	Mean	**38.50**	**58.53**	**48.52**	**32.89**	**52.71**	**42.80**	**31.35**	**51.41**	**41.38**	**34.25**	**54.22**	**44.24**
Mean Over Harvests	**5 m**	**27.64**	**47.54**	**37.59**	**23.20**	**42.98**	**33.09**	**20.37**	**40.32**	**30.35**	**23.73**	**43.61**	**33.67**
	12 m	**51.21**	**72.32**	**61.77**	**34.33**	**54.33**	**44.33**	**41.76**	**61.76**	**51.76**	**42.44**	**62.81**	**52.63**
Mean		**49.68**			**38.71**			**41.05**			**33.08**	**53.21**	

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 and Sprinklers

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Abstract

Two indigenous rangeland forage species viz. Cenchrus ciliaris L. (UAE) and Coelachyrum piercei L.(UAE) collected under ICARDA- APRP Phase- I have been investigated under ICARDA- APRP Phase-II 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) under two irrigation systems viz. drips and sprinklers respectively from May 2002 to November 2003 and November 2002 to March 2004 at Agriculture Research Station, Jimah in the Interior of Oman. The results of the investigations indicated the existence of differential expression of the seed related traits in three grass species studied in different times of harvests in both irrigation systems. The grass species produced higher seed yield (with husk) under wider row (100 cm) spacing than that under narrow row (50 cm). In both the irrigation systems Cenchrus ciliaris produced highest seed yield followed by Chloris gayana and Coelachyrum piercei. In drip irrigation system, Cenchrus ciliaris had produced higher seed yield of 340.67 kg/ha at 100 cm than at 50-cm row spacing (301.64 kg/ha). Chloris gayana had produced higher seed yield of 305.58 kg/ha at 100 cm than at 50-cm row spacing (292.50 kg/ha) while Coelachyrum piercei produced higher seed yield of 281.72 kg/ha at 100 cm than at 50-cm row-spacing (253.86). In sprinkler irrigation system, Cenchrus ciliaris had produced higher seed yield of 300.56 kg/ha at 100 cm than at 50-cm row spacing (267.74 kg/ha). Chloris gayana had produced higher seed yield of 283.19 kg/ha at 100 cm than at 50-cm row spacing (275.63 kg/ha) while Coelachyrum piercei produced higher seed yield of 260.56 kg/ha at 100 cm than at 50-cm row-spacing (225.63). Seed yield levels obtained under sprinkler irrigation system were lower than those obtained under drips.

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. Our investigations from 2001 to 2003 spanning nine harvests towards understanding the effect of inter-row and inter-plant spacing on seed yield and seed related traits have shown that the grass species gave 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 nine harvests) (474.58 kg/ha under 100 cm and 405.61 kg/ha under 50 cm row spacing) followed by Cenchrus ciliaris (442.76 kg/ha under 100 cm and 384.02 kg/ha under 50 cm row spacing) and Coelachyrum piercei (240.65 kg/ha under 100 cm and 198.59 kg/ha under 50 cm row spacing). In light of the above, the investigations were conducted from May 2002 to March 2004 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 two irrigation systems viz. drips and sprinklers. This report discusses results of the investigations spanning five seed harvests under drips and sprinklers, respectively.

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 and sprinkler systems separately during May and November 2002 respectively at Agriculture Research Station, Jimah located in the Interior of Oman. 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 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. Five seed harvests were taken up during the period of investigation under each irrigation system.

The observations on plant height (cm), total number of tillers/ plant, number of panicles per plant and seed yield per plot (g) were recorded at harvest. The experimental data of each irrigation system on above traits were subjected to ANOVA separately (as the crops of the two irrigation systems were planted on different dates), considering inter-row spacing, inter-plant spacing, grass species and harvests as factors using MSTAT-C computer program (Gomez and Gomez, 1984).

Results and Discussion

The results of the investigations under two irrigation systems viz. drips and sprinklers indicated the existence of differential expression of the seed related traits in three grass species studied in different times of harvests (Tables 1(a) and (b) to 5 (a) and 5(b)). Comparisons of results of the two irrigation systems made in this report are just are based on factual data for understanding the effect of inter-row and inter-plant spacing on seed yield and related traits, but are not statistical. The combined analysis of data has not been carried out because of differential age of the crops of the two irrigation systems.

Plant stand (%):

In respect of plant stand, effects of all main factors viz. harvest, inter-row spacing, inter-plant spacing and grass species, four 2-factor interactions viz. inter-row spacing x interplant spacing, harvest x grass species, inter-row spacing x grass species and interplant spacing x grass species and only one 3-factor interaction viz. inter-row spacing x inter-plant spacing x grass species, were highly significant ($p < 0.01$) under drips (Table 1(a)) while under sprinklers, effects of three main factors viz. harvest, inter-plant spacing and grass species, five

2-factor interactions viz. harvest x inter-row spacing, and inter-row spacing x inter-plant spacing, harvest x grass species, inter-row spacing x grass species and inter-plant spacing x grass species and two 3-factor interactions viz. harvest x inter-plant spacing x grass species and inter-row spacing x inter-plant spacing x grass species, were significant to highly significant ($p<0.05$) (Table 1(b)). Among the grasses, *Chloris gayana* and *Cenchrus ciliaris* had mostly 100 % plant stand up to last harvest. The plant stand of Coelachyrum got deteriorated in subsequent cuts to be about 96.30 to 96.40 % and 96.7 to 98.4 % in the last harvest in drips and sprinkler irrigation systems.

Plant Height:

In respect of plant height, effects of all the main factors except inter-plant spacing, effects of all the 2-factor interactions except that of harvest x inter-row spacing and effects of all 3-factor interaction except one such as harvest x inter-row spacing x grass species and the effect of 4-factor interaction, were significant to highly significant ($p<0.05$) under drip irrigation system (Table 2 (a)). Under sprinklers, effects of all the main factors except inter-plant spacing, effects of all 2 -factor interactions, effects of all 3-factor interactions except harvest x inter-row spacing x inter-plant spacing and harvest x inter-row spacing x grass species, were significant to highly significant ($p<0.05$) (Table 2 (b)). 4-factor interaction was however not significant ($p>0.05$) under sprinklers. Among the grass species, Cenchrus ciliaris recorded highest mean plant height of 124.13 cm at 100 cm row spacing and 122.36 cm at 50 cm row spacing followed by Chloris gayana (114.44 cm at 100 cm row spacing and 113.23 cm at 50 cm row spacing) under drips. Cenchrus ciliaris also recorded highest mean plant height of 118.22 cm at 100-cm row spacing and 117.94 cm at 50 cm row spacing followed by Chloris gayana (110.53 cm at 100 cm row spacing and 110.89 cm at 50 cm row spacing) under sprinklers. Coelachyrum piercei however recorded low plant height (< 85 cm) in both drips and sprinklers.

Number of tillers/ plant:

In respect of number of tillers per plant, effects of all main factors and that of 2-factor interactions viz. inter-row spacing x inter-plant spacing, harvest x grass species, inter-row spacing x grass species and inter-plant spacing x grass species, were highly significant ($p<0.01$) under drip irrigation system (Table 3 (a)). Under sprinklers, effects of all main factors and that of 2-factor interactions viz. harvest x inter-plant spacing, inter-row spacing x inter-plant spacing, harvest x grass species and inter-plant spacing x grass species, were highly significant ($p<0.01$) (Table 3 (b)). Among the inter-row spacing, 100 cm had significantly higher number of tillers (45.89 to 52.76 and 45.60 to 56.51) than 50 cm (43.61 to 49.85 and 42.83 to 52.78) in drips and sprinklers, respectively. Among the grass species, in 100-cm row spacing Cenchrus ciliaris (62.42 and 62.43) had significantly ($p<0.05$) more number of tillers than Coelachyrum piercei (43.58 and 42.48) in drips and sprinklers, respectively. Similar trend was observed in the grass species for 50-cm row spacing. In Chloris gayana, however, there was no significant difference between the row spacings in both irrigation systems.

Number of panicles/ plant:

In respect of number of panicles per plant, effects of all main factors and that of 2-factor interactions viz. inter-row spacing x inter-plant spacing, harvest x grass species, inter-row spacing x grass species and inter-plant spacing x grass species, were highly significant ($p<0.01$) under drip irrigation system (Table 4 (a)). Under sprinklers, effects of all main factors and that of 2-factor interactions viz. harvest x grass species and inter-plant spacing x grass species, and that of 3-factor interaction viz. inter-row spacing x inter-plant spacing x grass species, were highly significant ($p<0.01$) (Table 4 (b)). Among the inter-row spacing, 100 cm had significantly higher number of panicles (43.41 to 51.45 and 35.81to 47.79) than 50 cm (28.77 to 44.80 and 31.38 to 42.35) under drips and sprinklers, respectively. Among the grass species, in 100-cm row spacing, Chloris gayana (51.97 and 46.51) had significantly ($p<0.05$) more number of panicles than Cenchrus ciliaris (48.83 and 44.96) in drips and sprinklers, respectively. Similar trend was observed in the grass species for 50-cm row spacing. In Coelachyrum piercei however, there were significantly less number of panicles/ plant as compared to other two grass species in both irrigation systems.

Seed yield (with husk)/ ha:

In respect of seed yield/ha, effects of all the main factors and that of two 2-factor interactions viz. harvest and grass species and inter-row spacing x grass species, were highly significant ($p<0.01$) under drips (Tables 5 (a)). Under sprinklers, however, effects of all the main factors and that of three 2-factor interactions viz. harvest x inter-row spacing, harvest and grass species and inter-plant spacing x grass species, were highly significant ($p<0.01$) (Table 5 (b)). Among the inter-row spacing, 100 cm had significantly higher seed yield (279.33 to 347.59 kg/ha and 237.44 to 309.37 kg/ha) than 50 cm (262.41 to 320.78 kg/ha and 175.74 to 275.74 kg/ha) under drips and sprinklers, respectively. Among the grass species, in 100-cm row spacing, Cenchrus ciliaris (356.20 and 270.60 kg/ha) had significantly ($p<0.05$) higher seed yield than Chloris gayana (312.24 and 254.16 kg/ha) as compared to that in 50-cm row spacing (Cenchrus ciliaris -306.42 and 245.36 kg/ha; Chloris gayana- (299.58 and 242.69 kg/ha)) in drips and sprinklers, respectively. Coelachyrum piercei produced significantly lower yield than other grass species in all the harvests in both irrigation systems. The grass species gave high seed yield owing to the formation of more number of panicles under wider row (100 cm) spacing that had low plant density than that at narrow row spacing (50 cm). It is evident from the seed yield figures of all the grass species in the two irrigation systems that seed yield levels obtained under sprinkler irrigation system were lower than those obtained under drips. This is attributed to the fact that much of mature seeds were thrown on the ground from the panicles by the frequent hits of sprinkler drops.

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 results of the present investigations under both drips and sprinkler irrigation systems 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 (Tables 5((a) and (b)). Wider inter-row spacing has significantly ($p<0.05$) influenced in formation of more panicles and higher seed yield irrespective of grass species (Tables 4 and 5). 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 (Tables 5((a) and (b)). Boonman (1972) observed independence 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 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). In both the irrigation systems Cenchrus ciliaris produced highest seed yield followed by Chloris gayana and Coelachyrum piercei. In drip irrigation system, Cenchrus ciliaris had produced higher seed yield of 356.20 kg/ha at 100 cm than at 50-cm row spacing (306.42 kg/ha). Chloris gayana had produced higher seed yield of 312.24 kg/ha at 100 cm than at 50-cm row spacing (299.58 kg/ha) while Coelachyrum piercei produced higher seed yield of 291.91 kg/ha at 100 cm than at 50-cm row-spacing (264.87). In sprinkler irrigation system, Cenchrus ciliaris had produced higher seed yield of 270.60 kg/ha at 100 cm than at 50-cm row spacing (245.36 kg/ha). Chloris gayana had produced higher seed yield of 254.16 kg/ha at 100 cm than at 50-cm row spacing (242.69 kg/ha) while Coelachyrum piercei produced higher seed yield of 229.96 kg/ha at 100 cm than at 50-cm row-spacing (197.93). Seed yield levels obtained under sprinkler irrigation system were lower than those obtained under drips.

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

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Abstract

Two indigenous rangeland forage species viz. *Cenchrus ciliaris L.* (UAE) and *Coelachyrum piercei 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 to May 2004 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 results of the investigations spanning seven harvesting times up to May 2004 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 (55.67 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 (52.33 to 60.33 %) 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 42.00 to 46.00 % but at JRS, it was up to 35.00 to 39.00 %. 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 have clearly shown that seed in the grass species studied could be harvested just within couple of weeks after the crop attains physiological maturity to obtain optimum high quality seed yield under climatic conditions of Oman.

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 were conducted in two locations (Livestock Research Center (LRC), Rumais in the Batinah region and Agriculture Research Station (JRS), Jimah in the Interior region) from November 2002 to May 2004 under ICARDA-APRP Phase –II to know 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 investigations spanning seven harvesting times.

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

The present investigations were conducted from November 2002 to May 2004. At each harvest, forty inflorescences that had attained the stage of physiological maturity were randomly selected in each grass species and tagged by the white labels. The stage of physiological maturity (PM) was identified by senescence or drying of rachis of the inflorescence when mainly whole axis from the base of the rachis turns either straw colored or brittle or both). Ten tagged inflorescences in each grass species were collected at each of four 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 %.

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 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).

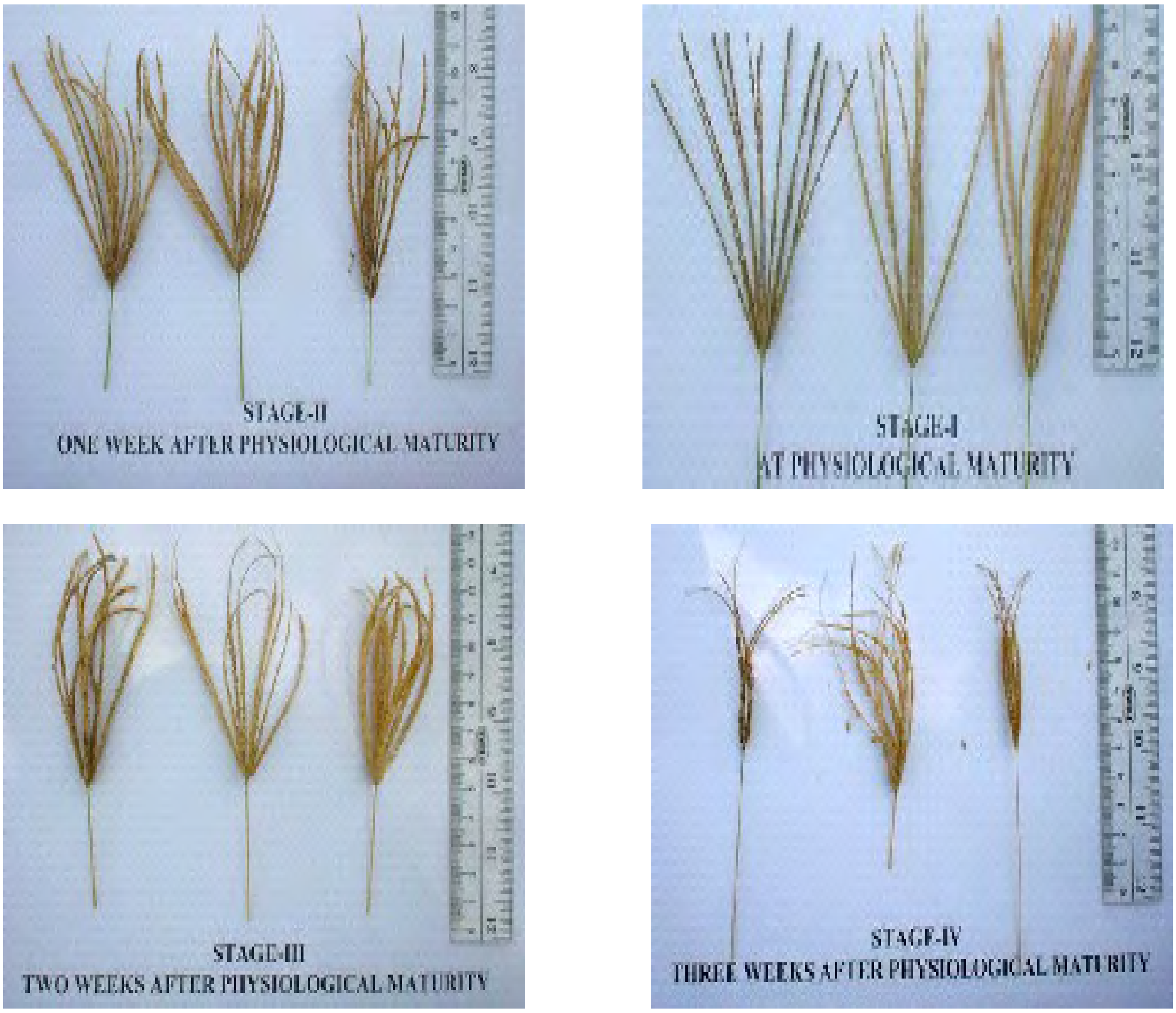

Plate 3. Different stages of maturity in Chloris gayana L.

Results and Discussion

The results of the investigations in two locations viz. LRC and JRS indicated the existence of differential expression of the seed related traits in three grass species studied at different 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 all main factors and effects of their two 2-factor interactions viz. harvesting time x grass species and grass species x maturity stage, were highly significant ($p<0.05$) in both the locations (Tables 3 (a) and (b)). The grass species behaved differentially in the formation of inflorescence in the two locations. In both the locations, *Cenchrus ciliaris* (238.35 mg at LRC and 240.31 mg at JRS) recorded significantly highest ($p<0.05$) mean inflorescence weight over harvesting times followed by *Chloris gayana* (192.19 mg at LRC and 200.13 mg at JRS) and *Coelachyrum piercei* (108.72 mg at LRC and 110.96 mg at JRS).

In both the locations, inflorescence weight of different harvesting times was not significant in respect of either *Cenchrus ciliaris* (208.64 to 262.87 mg at LRC and 192.97 to 261.10 mg at JRS) or in *Coelachyrum piercei* (90.37 to 123.73 mg at LRC and 87.29 to 134.15 mg at JRS) and *Chloris gayana* (148.95 to 234.49 mg at LRC and 142.60 to 244.32 mg at JRS).
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 (267.15 mg) to 1WAPM (258.26 mg), 2WAPM (220.10 mg) and 3WAPM (207.87 mg) at LRC. However, at JRS, the decline in inflorescence weight was although gradual but not significant only between PM (266.74 mg) and 1WAPM (260.53 mg). Similarly, in case of *Chloris gayana,* decrease in the weight of the inflorescence was significant ($p< 0.05$) from first (PM, 218.29 mg at LRC; 227.69 mg) to the last (3WAPM, 163.43 mg at LRC; 169.11 mg at JRS) stages of maturity in both the locations. In case of *Coelachyrum piercei*, however, decrease between the inflorescence weights of 1WAPM (110.17 mg at LRC and 113.04 mg at JRS) and 2WAPM (106.08 mg at LRC and 110.28 mg at JRS) was only not significant ($p>0.05$).

Seed 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* (214.60 mg at LRC and 188.52 at JRS) recorded significantly highest ($p<0.05$) mean seed weight over harvesting times followed by *Chloris gayana* (157.75 mg at LRC and 119.30 mg at JRS). *Coelachyrum piercei* recorded least seed weight (82.90 at LRC and 51.43 at JRS).
There was significant ($p<0.05$) difference in the seed weight between harvesting times in respect of all the grass species viz. *Cenchrus ciliaris* (182.65 to 244.31 mg at LRC and 154.09 to 205.50 mg at JRS), *Chloris gayana* (117.12 to 195.48 mg at LRC and 86.47 to 153.53 mg at JRS) and *Coelachyrum piercei* (50.86 to 123.73 mg at LRC and 43.07 to 60.09 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- 245.01 and 217.90 mg; 1WAPM-233.39 and 208.14 mg; 2WAPM-196.15 and 171.38 mg; 3WAPM-183.85 and 156.65 mg) but also in *Chloris gayana* ((PM- 182.73 and 147.00 mg; 1WAPM-166.87 and 127.34 mg; 2WAPM- 149.98 and 109.75 mg; 3WAPM-131.41 and 93.11 mg) respectively at LRC and JRS. In case of *Coelachyrum piercei*, however, decrease between the seed weights of 1WAPM (84.52 mg at LRC and 52.07 mg at JRS) and 2WAPM (79.55 mg at LRC and 51.31mg at JRS) was only not significant ($p>0.05$).

Seed recovery from inflorescence (%):

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

In all the grass species there was gradual and significant (p<0.05) decrease in the seed recovery from the stage of physiological maturity (PM) to the subsequent stages in both the locations. In case of *Cenchrus ciliaris,* the decrease was from 80.90 % (PM) to 72.65% (3WAPM) at LRC and from 81.70 % (PM) to 74.27 % (3WAPM) at JRS while in *Chloris gayana* it was from 65.30 % (PM) to 56.52 % (3WAPM) at LRC and from 64.56 % (PM) to 55.19 % (3WAPM) at JRS and in *Coelachyrum piercei,* the decrease was from 48.63 % (PM) to 41.37 % (3WAPM) at LRC and from 48.34 % (PM) to 43.29 % (3WAPM) at JRS. Such decrease in seed recovery in subsequent 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 interaction effect of harvesting time x grass species and that of grass species x maturity stage, were significant (p<0.05) only at JRS and ARC, respectively. The grass species behaved differentially with respect to germination (%) in the two locations at different times of harvest in different stages of maturity. At LRC, mean germination % among different harvesting times, varied from 48.83 to 54.67 %, from 46.83 to 54.00% and from 45.75 to 53.25 % in respect of *Cenchrus ciliaris, Coelachyrum piercei* and *Chloris gayana,* respectively. Interestingly, germination % of seed lots of harvests taken during November and February showed significantly (p<0.05) higher germination % in both the years at LRC but not at JRS.

In respect of germination % of different maturity stages in *Cenchrus ciliaris*, there was gradual and significant (p<0.05) increase in germination % from PM (40.81 %) to 2WAPM (58.57 %) and then it dropped significantly to 50.38% at 3WAPM at LRC but in JRS, germination % was found significantly increased (p<0.05) from PM (42.05 %) to 2WAPM (51.24 %), which then dropped significantly at 3WAPM (42.19 %). Increase in germination % from 1WAPM to 2WAPM was however, not significant (p>0.05). Other two grass species viz. *Coelachyrum piercei* and *Chloris gayana* had almost similar trend in germination % of different maturity stages as noticed in case of *Cenchrus ciliaris* in both the locations (Tables 6 (a) and (b)).

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 (55.67 to 69.00 %) 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 in the grass species studied (Figs. 1(a) and 1(b) for *Cenchrus ciliaris*, 2(a) and 2b) for *Coelachyrum piercei and 3*(a) and 3(b) for *Chloris gayana*). May or summer figures, on the other hand, were still quite interesting as the grass species had differential behavior in producing good quality seeds at the climates of LRC (hot and humid) and JRS (hot and dry) (Tables 6 (a) and (b)). In May, germination % was significantly higher (p<0.05) at 1WAPM (52.33 to 60.33 %) than that at preceding and succeeding stages, in general, in all the grass species and declined significantly in succeeding stages. At LRC, germination % recorded at 3WAPM was 42.00 to 46.00 % but at JRS, it was up to 35.00 to 39.00 % (Tables 6 (a) and (b)). This indicated that in summer seed deterioration was fast at JRS probably because of hot dry weather than that at LRC characterized by hot and humid weathers (Tables 1 and 2; Tables 6 (a) and (b)).

Grass seed growers often face substantial loss of good quality (viable) seeds while harvesting due to lack of knowledge about the appropriate harvesting time. It has been observed that some tropical grass species may produce good yields of seeds to the extent of 1000 kg/ha and above, but only a few proportion (may be 5-7% in *Setaria anceps*) is commercially recoverable (Chatterjee and Das, 1989). Reduction in seed weight from PM onwards is due to many reasons of which these two are of significance- i. Rapid loss of moisture content after full development of seed and ii. Shattering of seeds depending up on wind blows shortly after reaching maturity. Brzostowski and Owen (1966) found that seeds of *Cenchrus ciliaris* harvested at Kongwa, Tanzania, at the milky, cheesy and hard stages of seed, showed 83, 85 and 87 per cent viability after five months of harvest, indicating that hard stage was the best time of harvest. Hard stage can be comparable to either 1WAPM or 2WAPM in our studies at which sufficient moisture in the seed could be lost to become hard, due to high wind blows and hot air temperature of Oman. Chadhokar and Humphreys (1973) had recommended in their studies in *Paspalum plicatum* cv Rodds Bay that seed could be harvested when 5 % of the seed on the particular inflorescence is abscised. This is just similar to 1WAPM or 2WAPM (see Plates 1-3). Thus the present results have clearly shown that seed in the grass species studied, could be harvested just within couple of weeks after the crop attains physiological maturity to obtain optimum high quality seed yield under climatic conditions of Oman.

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Table 3(a). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and seven 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**
	H4 (Aug'03)	276.17	253.00	218.67	195.73	**235.89**
	H5 (Nov '03)	272.17	266.17	222.67	216.23	**244.31**
	H6 (Feb '04)	258.83	239.43	213.53	196.83	**227.16**
	H7 (May '04)	229.57	237.10	190.73	177.17	**208.64**
	Mean	**267.15**	**258.26**	**220.10**	**207.87**	**238.35**
Coelachyrum piercei L.	H1 (Nov '02)	137.60	111.00	112.80	88.00	**112.35**
	H2 (Feb '03)	120.40	115.63	110.10	96.30	**110.61**
	H3 (May '03)	142.47	114.53	116.87	92.03	**116.48**
	H4 (Aug'03)	137.70	132.67	119.33	105.20	**123.73**
	H5 (Nov '03)	136.53	106.73	98.77	87.13	**107.29**
	H6 (Feb '04)	114.47	102.97	96.33	87.23	**100.25**
	H7 (May '04)	114.17	87.67	88.33	71.30	**90.37**
	Mean	**129.05**	**110.17**	**106.08**	**89.60**	**108.72**
Chloris gayana L.	H1 (Nov '02)	232.87	208.00	191.77	167.43	**200.02**
	H2 (Feb '03)	259.57	256.70	225.47	196.23	**234.49**
	H3 (May '03)	225.13	197.97	183.83	160.30	**191.81**
	H4 (Aug'03)	204.03	195.17	176.33	164.17	**184.93**
	H5 (Nov '03)	213.00	196.00	183.33	166.33	**189.67**
	H6 (Feb '04)	220.67	210.33	186.33	164.60	**195.48**
	H7 (May '04)	172.77	154.40	143.67	124.97	**148.95**
	Mean	**218.29**	**202.65**	**184.39**	**163.43**	**192.19**

Statistical Parameters:

	F-Test	**LSD (5%)**
Harvesting time	**	5.36
Grass species	**	3.51
Harvesting time x Grass species	**	9.28
Maturity stage	**	4.05
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	7.01
Harvesting time x Maturity stage x Grass species	NS	-

Table 3(b). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and seven 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
	H4 (Aug'03)	286.03	284.80	227.00	208.43	251.57
	H5 (Nov '03)	271.93	266.33	229.13	222.43	247.46
	H6 (Feb '04)	258.83	252.77	221.30	202.00	233.73
	H7 (May '04)	215.50	204.00	180.43	171.93	192.97
	Mean	**266.74**	**260.53**	**222.94**	**211.03**	**240.31**
Coelachyrum piercei L.	H1 (Nov '02)	141.30	114.57	118.93	91.07	116.47
	H2 (Feb '03)	128.47	119.57	111.17	100.10	114.83
	H3 (May '03)	136.83	111.70	111.83	88.40	112.19
	H4 (Aug'03)	145.60	144.80	133.40	112.80	134.15
	H5 (Nov '03)	133.30	103.47	108.27	81.70	106.69
	H6 (Feb '04)	122.00	110.07	101.00	87.33	105.10
	H7 (May '04)	106.37	87.10	87.37	68.30	87.29
	Mean	**130.55**	**113.04**	**110.28**	**89.96**	**110.96**
Chloris gayana L.	H1 (Nov '02)	239.07	215.40	196.60	165.87	204.24
	H2 (Feb '03)	269.87	266.53	234.30	206.57	244.32
	H3 (May '03)	216.93	189.23	175.23	154.20	183.90
	H4 (Aug'03)	212.80	204.80	188.40	175.60	195.40
	H5 (Nov '03)	227.33	206.67	193.17	166.80	198.49
	H6 (Feb '04)	258.67	256.00	217.00	196.33	232.00
	H7 (May '04)	169.17	147.57	135.27	118.37	142.60
	Mean	**227.69**	**212.31**	**191.42**	**169.11**	**200.13**

Statistical Parameters:

	F-Test	LSD (5%)
Harvesting time	**	6.98
Grass species	**	4.58
Harvesting time x Grass species	**	12.11
Maturity stage	**	5.28
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	9.15
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	8.23	

Table 4(a). Means of seed weight) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and seven 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
	H4 (Aug'03)	276.17	253.00	218.67	195.73	235.89
	H5 (Nov '03)	272.17	266.17	222.67	216.23	244.31
	H6 (Feb '04)	258.83	239.43	213.53	196.83	227.16
	H7 (May '04)	229.57	237.10	190.73	177.17	208.64
	Mean	**245.01**	**233.39**	**196.15**	**183.85**	**214.60**
Coelachyrum piercei L.	H1 (Nov '02)	68.90	52.90	52.43	37.53	52.94
	H2 (Feb '03)	59.87	54.10	48.70	40.77	50.86
	H3 (May '03)	71.77	54.57	52.93	40.20	54.87
	H4 (Aug'03)	137.70	132.67	119.33	105.20	123.73
	H5 (Nov '03)	136.53	106.73	98.77	87.13	107.29
	H6 (Feb '04)	114.47	102.97	96.33	87.23	100.25
	H7 (May '04)	114.17	87.67	88.33	71.30	90.37
	Mean	**100.49**	**84.52**	**79.55**	**67.05**	**82.90**
Chloris gayana L.	H1 (Nov '02)	154.07	129.03	115.03	98.17	124.08
	H2 (Feb '03)	170.63	160.70	136.10	108.57	144.00
	H3 (May '03)	143.93	122.43	109.07	93.03	117.12
	H4 (Aug'03)	204.03	195.17	176.33	164.17	184.93
	H5 (Nov '03)	213.00	196.00	183.33	166.33	189.67
	H6 (Feb '04)	220.67	210.33	186.33	164.60	195.48
	H7 (May '04)	172.77	154.40	143.67	124.97	148.95
	Mean	**182.73**	**166.87**	**149.98**	**131.41**	**157.75**

Statistical Parameters:

	F-Test	LSD (5%)
Harvesting time	**	3.94
Grass species	**	2.58
Harvesting time x Grass species	**	6.84
Maturity stage	**	2.98
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	5.17
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	7.32	

Table 4(b). Means of seed weight) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass at four maturity stages and seven 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
	H4 (Aug'03)	227.97	228.77	176.10	156.37	197.30
	H5 (Nov '03)	219.03	210.00	173.73	159.57	190.58
	H6 (Feb '04)	211.93	202.13	166.33	140.33	180.18
	H7 (May '04)	178.10	166.37	139.37	132.53	154.09
	Mean	**217.90**	**208.14**	**171.38**	**156.65**	**188.52**
Coelachyrum piercei L.	H1 (Nov '02)	72.40	55.10	54.63	39.93	55.52
	H2 (Feb '03)	64.77	56.20	51.23	44.67	54.22
	H3 (May '03)	68.87	52.83	53.47	38.03	53.30
	H4 (Aug'03)	71.97	66.90	56.70	44.80	60.09
	H5 (Nov '03)	66.47	46.33	43.40	38.40	48.65
	H6 (Feb '04)	54.17	46.50	42.33	37.77	45.19
	H7 (May '04)	45.83	40.60	57.43	28.43	43.07
	Mean	**63.50**	**52.07**	**51.31**	**38.86**	**51.43**
Chloris gayana L.	H1 (Nov '02)	155.67	134.47	115.90	96.37	125.60
	H2 (Feb '03)	178.97	168.90	145.17	121.07	153.53
	H3 (May '03)	141.57	116.10	104.57	89.07	112.83
	H4 (Aug'03)	136.23	124.20	108.60	98.80	116.96
	H5 (Nov '03)	147.23	120.33	103.33	76.60	111.87
	H6 (Feb '04)	161.00	138.67	110.17	101.50	127.84
	H7 (May '04)	108.30	88.73	80.50	68.33	86.47
	Mean	**147.00**	**127.34**	**109.75**	**93.11**	**119.30**

Statistical Parameters:

	F-Test	LSD (5%)
Harvesting time	**	4.93
Grass species	**	3.23
Harvesting time x Grass species	**	8.54
Maturity stage	**	3.73
Harvesting time x Maturity stage	NS	-
Grass species x Maturity stage	**	6.45
Harvesting time x Maturity stage x Grass species	NS	-
CV (%)	8.91	

Influence of early and late forming tillers on Seed Weight *per se* and Seed Quality in Indigenous Rangeland and Forage Grass Species

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Abstract

Two indigenous rangeland forage species viz. *Cenchrus ciliaris L.* (UAE) and *Coelachyrum piercei 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 influence of early and late forming tillers on their seed weight (with husk) *per se* and seed quality from August 2003 to August 2004 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 both early and late forming tillers of three grass species were collected about one week after physiological maturity (1WAPM) of inflorescences early forming tillers. The results of the investigations spanning five harvests indicated the existence of differential expression of the seed related traits in three grass species studied in two types of tillers viz. early forming and late forming, in different times of harvests in both the locations. The above results indicated that early forming tillers possessed all seed related traits like inflorescence weight (mg), seed weight (with husk)/ inflorescence (mg), seed recovery (%) from inflorescence and germination % significantly superior to late forming tillers in respect of grass species studied. Hence, it is recommended that while harvesting seed in forage grass species emphasis should be given to harvest more proportion of seed from early formed tillers than from late formed tillers to get optimum quantity of better quality seed. The results have significance particularly in producing pre-basic, basic, breeder and foundation seed of grass species.

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. It has been observed in our bulk seed multiplication that shattering of seeds from the panicles of earlier forming tillers was enormous prior to maturity of panicles of later formed tillers in both *Cenchrus ciliaris* and *Coelachyrum piercei* as these are non-synchronous in panicle initiation of tillers. Hence, the investigations were conducted in two locations (Livestock Research Center (LRC), Rumais in the Batinah region and Agriculture Research Station (JRS), Jimah in the Interior region) from August 2003 to August 2004 under ICARDA-APRP Phase –II to know the influence of early and late-forming tillers on quantity and quality of seed in the indigenous rangeland and forage grass species. This report discusses results of the investigations spanning five harvests.

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. The present investigations were conducted from August 2003 to August 2004. At each harvest, ten samples of inflorescences of both early and late forming tillers of three grass species were collected about one week after physiological maturity (1WAPM) of inflorescences early forming tillers. These inflorescences were dried under shade for about two weeks when they were expected to possess about 10-12% moisture %.
The observations on inflorescence weight (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 nature of tiller, as factors in CRD using MSTAT-C computer program (Gomez and Gomez, 1984).

Results and Discussion

The results of the investigations spanning five harvests indicated the existence of differential expression of the seed related traits in three grass species studied in two types of tillers viz. early forming and late forming, in different times of harvests in both the locations (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 all main factors and their interactions were highly significant ($p<0.01$) at LRC (Table 1 (a)) while at JRS, all the effects except that of interactions viz. harvest x tiller type and harvest x grass species x tiller type, were highly significant ($p<0.05$) in both the locations (Tables 1 (b)). Inflorescence weight of harvests were significantly different ($p<0.05$) for grass species in both the locations. The inflorescence weight ranged from 248.20 to 255.67 mg in *Cenchrus ciliaris*, 120.30 to 153.15 mg in *Coelachyrum piercei* and 184.00 to 201.78 mg in *Chloris gayana* at LRC. However, at JRS, the inflorescence weight ranged from 207.80 to 248.63 mg in *Cenchrus ciliaris*, 125.28 to 150.57 mg in *Coelachyrum piercei* and 175.25 to 186.87 mg in *Chloris gayana*.
Among the grass species, *Cenchrus ciliaris* recorded significantly ($p<0.05$) highest inflorescence weight (248.77 mg at LRC and 229.22 mg at JRS) followed by *Chloris gayana* (190.88 mg at LRC and 180.82 mg at JRS) and *Coelachyrum piercei* (140.15 mg at LRC and 140.81 mg at JRS) at both the locations.
Among the tiller types, early forming tillers had significantly ($p< 0.05$) higher inflorescence weight than late forming tillers in three grass species studied. At LRC, *Cenchrus ciliaris* recorded significantly ($p<0.05$) highest inflorescence weight in early forming tillers (280.76 mg at LRC and 258.47 mg at JRS) than late forming tillers (216.78 mg at LRC and 199.96 mg at JRS) followed by *Chloris gayana* (229.33 mg at LRC and 241.15 mg at JRS from early tillers; 152.44 mg at LRC and 120.49 mg at JRS from late tillers) and *Coelachyrum piercei* (152.05 mg at LRC and 154.64 mg at JRS from early tillers; 126.97 mg at LRC and 126.97 mg at JRS from late tillers).

Seed weight (with husk) / inflorescence (mg):

In respect of seed weight, the effects of all main factors and their interactions were highly significant (p<0.01) at both locations (Tables 2 (a)) and 2(b). Seed weight of harvests were significantly different (p<0.05) for grass species in both the locations. The seed weight ranged from 188.78 to 205.57 mg in *Cenchrus ciliaris*, 60.40 to 76.28 mg in *Coelachyrum piercei* and 93.63 to 147.30 mg in *Chloris gayana* at LRC. However, at JRS, seed weight ranged from 162.00 to 186.53 mg in *Cenchrus ciliaris*, 62.35 to 73.27 mg in *Coelachyrum piercei* and 59.12 to 120.12 mg in *Chloris gayana.*

Among the grass species, *Cenchrus ciliaris* recorded significantly (p<0.05) highest seed weight (194.97 mg at LRC and 173.94 mg at JRS) followed by *Chloris gayana* (118.66 mg at LRC and 100.57 mg at JRS) and *Coelachyrum piercei* (70.61 mg at LRC and 68.42 mg at JRS) at both the locations.

Among the tiller types, early forming tillers had significantly (p< 0.05) higher seed weight than late forming tillers in three grass species studied. At LRC, *Cenchrus ciliaris* recorded significantly (p<0.05) highest seed weight in early forming tillers (231.81 mg at LRC and 214.03 mg at JRS) than late forming tillers (158.14 mg at LRC and 133.66 mg at JRS) followed by *Chloris gayana* (140.58 mg at LRC and 134.07 mg at JRS from early tillers; 96.75 mg at LRC and 67.08 mg at JRS from late tillers) and *Coelachyrum piercei* (74.82 mg at LRC and 76.89 mg at JRS from early tillers; 66.39 mg at LRC and 59.95 mg at JRS from late tillers).

Seed recovery from inflorescence (%):

In respect of seed recovery from inflorescence (%), the effects of all main factors except harvest and their interactions were highly significant (p<0.01) at JRS (Table3 (b)) while at LRC, only the effects of two main factors viz. harvest and grass species were highly significant (p<0.01) (Table 3 (a). Seed recovery in the grass species from harvests were significantly different (p<0.05) only at LRC where the seed recovery ranged from 74.57 to 79.39 % in *Cenchrus ciliaris*, 49.48 to 51.90 % in *Coelachyrum piercei* and 53.54 to 71.70 % in *Chloris gayana.*

Among the grass species, *Cenchrus ciliaris* recorded significantly (p<0.05) highest seed recovery (77.76 % at LRC and 77.30 % at JRS) followed by *Chloris gayana* (62.42 % at LRC and 59.74 % at JRS) and *Coelachyrum piercei* (50.52 % at LRC and 48.53 % at JRS) at both the locations.

Among the tiller types, early forming tillers had significantly (p< 0.05) higher seed recovery than late forming tillers in three grass species studied only at JRS. At JRS, *Cenchrus ciliaris* recorded significantly (p<0.05) highest seed recovery in early forming tillers (84.57 %) than late forming tillers (70.03 %) followed by *Chloris gayana* (63.81 % from early tillers; 55.67 % from late tillers) and *Coelachyrum piercei* (49.81 % from early tillers; 47.25 % from late tillers).

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 seed germination (%), the effects of all main factors except that of interactions viz. grass species x tiller type and harvest x grass species x tiller type, were highly significant (p<0.01) at LRC (Table 4 (a)) while at JRS, only the effects of two main factors viz. grass species and tiller type and 2-factor interactions viz. harvest x grass species and harvest x tiller type, were highly significant (p<0.01) (Table 3 (b). Seed germination in the grass species from harvests were significantly different (p<0.05) only at LRC where germination ranged from 38.17 to 39.00 % in *Cenchrus ciliaris*, 34.17 to 38.33 % in *Coelachyrum piercei* and 36.33 to 41.17 % in *Chloris gayana.* Among the grass species, at LRC *Chloris gayana* (39.53 %) recorded significantly (p<0.05) higher seed germination than

Coelachyrum piercei (36.30 %). However, its seed germination was on par with *Chloris gayana* (38.80 %). At JRS, *Cenchrus ciliaris* recorded significantly ($p<0.05$) highest seed germination as compared to *Chloris gayana* (36.97 %) and *Coelachyrum piercei* (36.33 %) while *Chloris gayana* (36.97 %) and *Coelachyrum piercei* (36.33%) were on par with each other for seed germination %. Among the tiller types, early forming tillers had significantly ($p< 0.05$) higher germination % than late forming tillers in three grass species studied. At LRC, *Chloris gayana* recorded significantly ($p<0.05$) highest germination in early forming tillers (42.87 %) than late forming tillers (36.20 %) followed by *Cenchrus ciliaris* (41.67 % from early tillers; 35.93 % from late tillers) and *Coelachyrum piercei* (39.93 % from early tillers; 32.67 from late tillers). However, at JRS *Cenchrus ciliaris* recorded significantly ($p<0.05$) highest germination in early forming tillers (42.93 %) than late forming tillers 36.47 %) followed by *Coelachyrum piercei* (41.20 % from early tillers; 33.60 % from late tillers) and *Chloris gayana* (41.13 % from early tillers; 32.80 from late tillers). The above results clearly indicated that early forming tillers possessed all seed related traits like inflorescence weight (mg), seed weight (with husk)/ inflorescence (mg), seed recovery (%) from inflorescence and germination % significantly superior to late forming tillers in respect of grass species studied. For instance, this is also evident from the Plates 1, 2 and 3 that show relative sizes of sampled inflorescences harvested from early and late formed tillers in *Cenchrus ciliaris, Coelachyrum piercei* and *Chloris gayana.* Such existence of difference in the in the quantity and quality of seed produced from the early and late-formed tillers has been also noted in the pasture grass spceies like *Paspalum plicatum* and *Setaria anceps.* In these species, early-formed inflorescence was found to contain more and larger seed of high quality than the late-formed inflorescences earlier (Chadhokar and Humphreys, 1973 and Chatterjee and Das, 1989). 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). This is mainly attributed to shattering of seeds from the early-formed tillers depending up on wind blows shortly after reaching maturity. Hence, it is recommended that while harvesting seed in forage grass species emphasis should be given to harvest more proportion of seed from early formed tillers than from late formed tillers to get optimum quantity of better quality seed. The results have significance particularly in producing pre-basic, basic, breeder and foundation seed of grass species.

PLATE 1. Early- and late-formed tillers of Cenchrus ciliaris L.

EARLY - FORMED TILLERS ***LATE - FORMED TILLERS***

PLATE 2. Early- and late-formed tillers of Coelachyrum piercei L.

EARLY - FORMED TILLERS

LATE - FORMED TILLERS

PLATE 3. Early- and late-formed tillers of Chloris gayana L.

EARLY - FORMED TILLERS

LATE - FORMED TILLERS

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Table 1(a). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at LRC, Rumais

	Harvests	Inflorescence weight (mg) /per se		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	280.07	218.57	249.32
	November 2003	292.17	219.17	255.67
	February 2004	278.83	217.57	248.20
	May 2004	282.50	219.43	250.97
	August 2004	270.23	209.17	239.70
	Mean	280.76	216.78	248.77
Coelachyrum piercei L.	August 2003	164.43	141.87	153.15
	November 2003	149.30	123.03	136.17
	February 2004	134.47	106.13	120.30
	May 2004	155.17	130.50	142.83
	August 2004	156.90	139.67	148.28
	Mean	152.05	128.24	140.15
Chloris gayana L.	August 2003	214.83	161.17	188.00
	November 2003	251.17	152.40	201.78
	February 2004	240.67	133.07	186.87
	May 2004	228.97	158.57	193.77
	August 2004	211.00	157.00	184.00
	Mean	229.33	152.44	190.88

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	6.13
Grass species	**	4.75
Harvest x Grass species	**	10.62
Tiller type	**	3.88
Harvest x Tiller type	**	8.67
Grass species x Tiller type	**	5.28
Harvest x Grass species x Tiller type	**	14.99
CV (%)	4.85	

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* Significant at 0.05 level of probability
**- Significant at 0.01 level of probability

Table 1(b). Means of inflorescence weight (mg) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at JRS, Interior

Grass Species	Harvests	Inflorescence weight (mg) per se		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	244.63	189.37	217.00
	November 2003	283.93	213.33	248.63
	February 2004	275.83	214.80	245.32
	May 2004	254.33	200.33	227.33
	August 2004	233.63	181.97	207.80
	Mean	**258.47**	**199.96**	**229.22**
Coelachyrum piercei L.	August 2003	165.30	135.83	150.57
	November 2003	157.47	130.83	144.15
	February 2004	137.83	112.73	125.28
	May 2004	160.83	129.40	145.12
	August 2004	151.77	126.07	138.92
	Mean	**154.64**	**126.97**	**140.81**
Chloris gayana L.	August 2003	235.27	127.70	181.48
	November 2003	247.07	116.83	181.95
	February 2004	258.50	115.23	186.87
	May 2004	236.77	120.33	178.55
	August 2004	228.17	122.33	175.25
	Mean	241.15	120.49	180.82

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	7.07
Grass species	**	5.48
Harvest x Grass species	**	12.25
Tiller type	**	4.47
Harvest x Tiller type	NS	-
Grass species x Tiller type	**	7.75
Harvest x Grass species x Tiller type	NS	-
CV (%)	5.90	

Table 2(a). Means of seed weight (with husk) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at LRC, Rumais

Grass Species	Harvests	Seed weight (with husk)/ inflorescence (mg)		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	232.43	165.07	198.75
	November 2003	254.83	156.30	205.57
	February 2004	226.37	159.60	192.98
	May 2004	225.57	152.00	188.78
	August 2004	219.83	157.73	188.78
	Mean	**231.81**	**158.14**	**194.97**
Coelachyrum piercei L.	August 2003	80.93	71.63	76.28
	November 2003	74.37	66.30	70.33
	February 2004	68.07	52.73	60.40
	May 2004	71.00	69.23	70.12
	August 2004	79.73	72.07	75.90
	Mean	**74.82**	**66.39**	**70.61**
Chloris gayana L.	August 2003	132.53	102.37	117.45
	November 2003	193.63	100.97	147.30
	February 2004	102.70	84.57	93.63
	May 2004	144.13	94.67	119.40
	August 2004	129.90	101.17	115.53
	Mean	**140.58**	**96.75**	**118.66**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	11.01
Grass species	**	8.53
Harvest x Grass species	**	19.07
Tiller type	**	6.96
Harvest x Tiller type	**	15.57
Grass species x Tiller type	**	12.06
Harvest x Grass species x Tiller type	NS	-
CV(%)	13.16	

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* Significant at 0.05 level of probability
**- Significant at 0.01 level of probability

Table 2(b). Means of seed weight (with husk) / inflorescence (mg) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at JRS, Interior

Grass Species	Harvests	Seed weight (with husk)/ inflorescence (mg)		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	231.83	141.23	186.53
	November 2003	231.83	141.23	186.53
	February 2004	225.97	146.40	186.18
	May 2004	205.50	131.67	168.58
	August 2004	195.17	137.67	166.42
	Mean	**218.06**	**139.64**	**178.85**
Coelachyrum piercei L.	August 2003	81.87	64.67	73.27
	November 2003	78.53	64.67	71.60
	February 2004	70.27	55.20	62.73
	May 2004	81.10	63.17	72.13
	August 2004	72.67	52.03	62.35
	Mean	**76.89**	**59.95**	**68.42**
Chloris gayana L.	August 2003	156.30	62.00	109.15
	November 2003	56.30	61.93	59.12
	February 2004	175.00	65.23	120.12
	May 2004	146.57	74.17	110.37
	August 2004	136.17	72.07	104.12
	Mean	**134.07**	**67.08**	**100.57**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	5.56
Grass species	**	4.31
Harvest x Grass species	**	9.64
Tiller type	**	3.52
Harvest x Tiller type	**	7.87
Grass species x Tiller type	**	6.10
Harvest x Grass species x Tiller type	**	13.63
CV(%)	7.14	

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* Significant at 0.05 level of probability
** Significant at 0.01 level of probability

Table 3(a). Means of seed recovery from inflorescence (%) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at LRC, Rumais

Grass Species	Harvests	Seed recovery from inflorescence (%)		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	82.99	75.51	79.25
	November 2003	87.42	71.37	79.39
	February 2004	81.14	73.33	77.24
	May 2004	79.89	69.26	74.57
	August 2004	81.35	75.37	78.36
	Mean	**82.56**	**72.97**	**77.76**
Coelachyrum piercei L.	August 2003	49.26	50.50	49.88
	November 2003	49.83	53.96	51.90
	February 2004	50.65	49.67	50.16
	May 2004	45.91	53.06	49.48
	August 2004	50.83	51.60	51.21
	Mean	**49.30**	**51.75**	**50.52**
Chloris gayana L.	August 2003	61.65	63.56	62.61
	November 2003	77.11	66.29	71.70
	February 2004	43.51	63.57	53.54
	May 2004	62.87	59.72	61.29
	August 2004	61.52	64.37	62.95
	Mean	**61.33**	**63.50**	**62.42**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	4.55
Grass species	**	3.52
Harvest x Grass species	NS	-
Tiller type	NS	-
Harvest x Tiller type	NS	-
Grass species x Tiller type	NS	-
Harvest x Grass species x Tiller type	NS	-
CV (%)	10.95	

* Significant at 0.05 level of probability
** Significant at 0.01 level of probability

Table 3(b). Means of seed recovery from inflorescence (%) of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at JRS, Interior

Grass Species	Harvests	Seed Recovery from Inflorescence (%)		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	94.84	74.55	84.70
	November 2003	81.66	66.08	73.87
	February 2004	81.95	68.08	75.01
	May 2004	80.82	65.78	73.30
	August 2004	83.57	75.65	79.61
	Mean	**84.57**	**70.03**	**77.30**
Coelachyrum piercei L.	August 2003	49.81	47.88	48.85
	November 2003	49.88	49.42	49.65
	February 2004	50.98	48.97	49.97
	May 2004	50.50	48.64	49.57
	August 2004	47.88	41.31	44.60
	Mean	**49.81**	**47.25**	**48.53**
Chloris gayana L.	August 2003	66.58	48.58	57.58
	November 2003	63.25	53.03	58.14
	February 2004	67.68	56.42	62.05
	May 2004	61.89	61.63	61.76
	August 2004	59.64	58.70	59.17
	Mean	**63.81**	**55.67**	**59.74**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	NS	-
Grass species	**	1.68
Harvest x Grass species	**	3.76
Tiller type	**	1.37
Harvest x Tiller type	**	3.07
Grass species x Tiller type	**	2.37
Harvest x Grass species x Tiller type	**	5.32
CV(%)	5.37	

* Significant at 0.05 level of probability
**- Significant at 0.01 level of probability

Table 4(a). Means of germination % of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at LRC, Rumais

Grass Species	Harvests	Germination %		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	42.33	34.00	38.17
	November 2003	41.00	36.67	38.83
	February 2004	40.67	37.33	39.00
	May 2004	41.33	36.67	39.00
	August 2004	43.00	35.00	39.00
	Mean	**41.67**	**35.93**	**38.80**
Coelachyrum piercei L.	August 2003	42.00	30.67	36.33
	November 2003	38.67	33.00	35.83
	February 2004	39.00	34.67	36.83
	May 2004	35.00	33.33	34.17
	August 2004	45.00	31.67	38.33
	Mean	**39.93**	**32.67**	**36.30**
Chloris gayana L.	August 2003	44.00	37.00	40.50
	November 2003	43.33	39.00	41.17
	February 2004	42.67	35.33	39.00
	May 2004	38.33	34.33	36.33
	August 2004	46.00	35.33	40.67
	Mean	**42.87**	**36.20**	**39.53**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	**	1.38
Grass species	**	1.07
Harvest x Grass species	**	2.40
Tiller type	**	0.87
Harvest x Tiller type	**	1.95
Grass species x Tiller type	NS	-
Harvest x Grass species x Tiller type	NS	-
CV(%)	5.54	

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* Significant at 0.05 level of probability
**- Significant at 0.01 level of probability

Table 4(b). Means of germination % of two indigenous rangeland forage grass species and Rhodes grass of two tiller types at five harvests at JRS, Interior

Grass Species	Harvests	Germination %		
		Early	Late	Mean
Cenchrus ciliaris L	August 2003	39.67	35.00	37.33
	November 2003	39.67	35.00	37.33
	February 2004	40.00	36.67	38.33
	May 2004	47.67	38.33	43.00
	August 2004	47.67	37.33	42.50
	Mean	**42.93**	**36.47**	**39.70**
Coelachyrum piercei L.	August 2003	40.00	35.33	37.67
	November 2003	40.00	35.33	37.67
	February 2004	39.33	35.00	37.17
	May 2004	46.00	30.33	38.17
	August 2004	40.67	32.00	36.33
	Mean	**41.20**	**33.60**	**37.40**
Chloris gayana L.	August 2003	41.33	35.00	38.17
	November 2003	41.33	35.00	38.17
	February 2004	37.67	33.00	35.33
	May 2004	42.33	32.00	37.17
	August 2004	43.00	29.00	36.00
	Mean	**41.13**	**32.80**	**36.97**

Statistical Parameters:

	F-Test	LSD (5%)
Harvest	NS	-
Grass species	**	1.42
Harvest x Grass species	**	3.18
Tiller type	**	1.16
Harvest x Tiller type	**	2.59
Grass species x Tiller type	NS	-
Harvest x Grass species x Tiller type	NS	-
CV(%)	7.40	

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* Significant at 0.05 level of probability
**- Significant at 0.01 level of probability

Morphological Characterization of Three Rangeland Grass Species

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Abstract

Investigations on characterization of three perennial rangeland forage species namely Lasiurus hirsutus L. (Mahara accession), Panicum turgidum L. (Mahara accession)) and Pennisetum divisum L. (Mahara accession) were undertaken during 2003-2004 by using representative samples taken at different growth stages. The accession of Lasiurus hirsutus L was characterized in respect of as many as 19 pigmentation characters and 8 morphological traits while the accessions of Panicum turgidum L. and Pennisetum divisum L. 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 Jabel 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 are being conducted since 2001-2002. During 2001-02, 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 morphological traits. However, Coelachyrum piercei was characterized in respect of 12 pigmentation characters and 8 morphological traits. Investigations on characterization of two perennial rangeland forage species namely Lasiurus hirsutus L.(Buraimi accession) and Panicum turgidum L. (Buraimi and Izki accessions) were further undertaken during 2002-2003. 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) of Panicum turgidum L. were characterized in respect of as many as 19 pigmentation characters and 11 morphological traits. In continuation of these studies, three perennial rangeland forage species namely Lasiurus hirsutus L. (Mahara accession), Panicum turgidum L. (Mahara accession) and Pennisetum divisum (Mahara accession) were considered for characterization during 2003-2004.

Materials and Methods

Representative samples of three perennial rangeland forage species namely *Lasiurus hirsutus L.* (Mahara accession), Panicum turgidum L. (Mahara accession) and *Pennisetum divisum* (Mahara accession) grown in pots under shade house at Agriculture Research Center, Rumais were collected at different growth stages in both winter and summer of 2003-2004. 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 three perennial rangeland forage species namely Lasiurus hirsutus L. (Mahara accession), Panicum turgidum L. (Mahara accession) and Pennisetum divisum (Mahara accession) in respect of morphological and pigmentation characters (Tables 1-3). The accession of Lasiurus hirsutus L was characterized in respect of as many as 19 pigmentation characters and 8 morphological traits while the accessions of Panicum turgidum L. and Pennisetum divisum L. 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. (Mahara accession)

Marker Characters:	*Lasiurus hirsutus* (Mahara 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
12. Juctura	Colourless
13. Junctura Back	Colourless
14. Panicle puvinus	Green
15. Panicle axis	Green
16. Lemma/palea	Light purple
17. Anther colour	Green to Yellow
18. Stigma	Hairy, colourless
19. Seed color	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.(Mahara accession)

Marker Characters:	*Panicum turgidum* (Mahara 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 to orange
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 Pennisetum divisum L. (Mahara accession)

Marker Characters:	***Pennisetum divisum*** (Mahara 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 (Orange)
19. Seed color	Brownish black
II. Morphological characters:	
1. Leaf blade	Short
2. Flag leaf	Very short
3. Nodal nature	Bent
4. Plant Height	Tall (125 -135 cm)
5. Panicle type	Lax
6. Awns	Present
7. Stigma	Bifid, hairy
8. Panicle length	Long (> 10 cm)
9. Panicle exsertion	High
10. Shattering of seeds	More
11. Seed size	Small to medium

Response of Indigenous Rangeland Forage Species to Salinity Imposed from germination stage

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Abstract

Two indigenous rangeland forage species viz. *Cenchrus ciliaris L.* (UAE) and *Coelachyrum piercei 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 to April 2004. The results of the study spanning 25 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 piercei 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 C*enchrus species* and *Coelachyrum piercei 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 Jabel 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 fusca Kunth)* = Alfalfa *(Medicago sativa L.).* Our previous study on response of these grass species to salinity imposed after the first cut indicated that Rhodes grass cultivars were distinctly superior in their tolerance to salinity followed by Australian *Cenchrus*, local *Cenchrus* and *Coelachyrum piercei*. Further, it was noticed that these grass species survived under higher salinity levels even up to a minimum of eight cuts (Nadaf *et al.*, 2002)
In light of the above, the investigations were conducted for more than two years spanning 25 cuts from October 2001 to April 2004 under ICARDA-APRP Phase –II to study the response of indigenous rangeland species along with Australian Buffel and Rhodes grass cultivars to varying levels of salinity imposed right from germination stage and assess their salinity tolerance for their utilization either in existing forage production system or for rangeland enhancement/ rehabilitation. This report discusses results of the investigations spanning 25 cuts about the effects of different levels of irrigation water salinity on agronomic attributes in indigenous and cultivated forage species.

Materials and Methods

The forage 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 two cultivated varieties of Rhodes grass (*Chloris gayana* Kunth.)- Katambora and Callide and a Buffel grass (*Cenchrus ciliaris L.)* variety of Australia. The physical and chemical characteristics of the experimental soil and the chemical characteristics of irrigation water treatments are presented respectively in Tables 1 and 2. The trial was laid in two factor completely randomized design with three replications using five forage species under five levels of irrigation water salinity viz. Control (1dS m^{-1}), 3, 6, 9, 12, 15, 18 dS m^{-1}) in pots of 30 cm diameter on October, 2001. Four plants grown in each pot were fertilized with the recommended dose of 1200 kg N, 150 kg P_2O_5 and 150 kg K_2O/ha for Rhodes grass in the form of urea, triple super phosphate and potassium sulphate, respectively. The entire quantities of P and 1/10 of N and K fertilizers were applied before planting while the remaining N and K fertilizers were applied in equal splits (i.e. 1/10 N and 1/10 P) subsequently after each forage harvest (cut). The salinity treatments were imposed right from germination stage, which were prepared in 100-liter iron drums by diluting seawater (48.5 ± 2 dS m^{-1}) as it incorporates several salt compositions commonly encountered in saline soils, namely high concentrations of sodium, chloride, sulphate and boron and a low calcium to magnesium ratio. The electrical conductivity was measured by conductivity TDS meter model 44600 (Hach). The pots of each species were frequently irrigated with respective water lightly till germination and later thrice a week till first harvest of forage at 20-50 % blooming during January 2002. Subsequent cuts were taken in each species at blooming. The observations on plant height (cm), number of tillers/ plant, green matter weight (g)/ plant and dry matter weight (g)/ plant were recorded at each cut. The dry matter weight (g) was recorded in the laboratory after drying green matter in the oven at 70 C for 18-24 hrs. The data were subjected to ANOVA considering salinity, species and cuts as factors using MSTAT-C computer program (Gomez and Gomez, 1984). A stress susceptibility index, S for the genotypes was determined on the basis of all agronomic traits in the high salinity irrigation treatment relative to low saline (control) treatment (Fischer and Maurer, 1978; Kelman and Qualset, 1991). The S is defined as: $S = [1- (Y_{ij} / Y_{ic})] / [1- (Y_{.j} / Y_{.c})]$, where Y_{ij} = character expression of ith genotype in the jth saline treatment, Y_{ic} = character expression of the same genotype in the control treatment, $Y_{.j}$ = mean character expression of all the genotypes in the jth saline treatment, and $Y_{.c}$ = mean character expression of all the genotypes in the control treatment. Low S values indicate low susceptibility or high tolerance to environmentally induced stress like salinity.

Results and Discussion

The results of the study indicated that the 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. However, stress susceptibility index values were found to vary for each character among the species with different levels of salinity.

Germination:

Rhodes grass cultivars were the only grass species, which germinated in all the salinity levels while germination of other grass species, was severely affected especially in higher salinity levels. *Coelachyrum piercei* did not germinate in 9 dS m^{-1} and above while Australian *Cenchrus* did not germinate in 12 dS m^{-1} and above and Local Cenchrus did not germinate in 15 dS m^{-1} and above.

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 twenty-fifth 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 twenty-forth 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}. Rhodes grass variety Callide, however, died completely after 24 th cut (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 67.21 cm at control as compared to 20.75 cm at 6 dS m^{-1} while indigenous *Cenchrus ciliaris* had a low plant height of 0.28 cm at 12 dS m^{-1} as against 65.24 cm at control. Australian Buffel had a moderate effect of salinity in respect of plant height (64.96 cm at control vs 5.71 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 and 6 dS m^{-1} in respect of plant height (83.60 and 71.05 cm) as against 91.80 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 28.55 at control to 6.95 at 6 dS m^{-1} in *Coelachyrum piercei* while it was reduced from 43.21 at control to 0.08 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 (41.64 at control vs 0.56 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, Katambora had 9.34 tillers per plant at 6 dS m^{-1} as against 33.95 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 57.28 and 16.86 g at control as compared to 7.54 and 3.03 g at 6 dS m^{-1}. Indigenous *Cenchrus ciliaris* had low green and dry matter weights of 1.30 and 0.49 g at 9 dS m^{-1} as against 103.69 and 37.64 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 110.25 and 38.73 g at control as compared to 43.41 and 13.41 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 168.59 and 59.86 g at control as compared to 87.64 and 26.58 g at 6 dS m^{-1} while Callide had low green and dry matter weights of 53.60 and 17.79 g at 6 dS m^{-1} as against 152.23 and 48.52 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.

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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

Adaptation of Intensive Hydroponics Vertical System for the Production of Strawberry (*Fragaria* X *Ananassa*) under Non –Cooled Green Hall

Muthir S.S Al Rawahy, Fatma M. Al Raisy, Salem M. Al Makhmmari, Dr. Ahmed albakry Eng. Khair albusaidi

Abstract

Three strawberry varieties viz. Selected Tahriry, Chandler and Camarosa were evaluated for their yield performance and quality attributes using hydroponics vertical system techniques at Agricultural research centre (ARC) during 2003/2004 season. The experiment was replicated three times in RCD. The results revealed that a significant ($P<0.05$) differences were observed in yield and average fruit weight between the varieties. Highest yield was given by Selected Tahriry (2.2 t/720 m2). Total soluble solids varied from 7.0 to 8.2% among the varieties.

Introduction

Strawberry crop belongs to the family Rosaceae (Rose) and genus Fragaria. Strawberry is a high cash value crop and it is used in many ways such as table fruits, making juice, jam etc. It is sensitive to salinity and it grows well in a cool and moist climate. It can be planted in open field and protected agriculture, as well as in different types of soil less culture techniques .Vertical system is a technique of soil less culture in which the plants are grown in the pots arranged vertically one above another (overlapping) in the form of a column. It is economical way of cultivation saving land, water and fertilizers. In light of the above, experiment was conducted to adapt hydroponics vertical system and evaluate the strawberry varieties under such system.

Materials and Methods

The experiment was carried out in non cooled green hall of an area 1440 m2.The crop was planted in an area of 720 m2 by using vertical system which consists of 13 channels (rows), each row containing 30 columns. Each column contained 8 pots. Mixture of 1:1 ratio of peat-moss and perlite were used as a media to fill in the pots. The prechiling plants were planted on 31/12/2003 in a complete randomized design (CRD) with three replications at a spacing 1.2 m between channels and 83 cm between columns. Number of plants in each pot was 4. Total number of plants was 12480. The system was equipped with automatic irrigation system controlled by the timers. The crop was irrigated four times daily for a period of one minute and increased according to the weather and crop requirement. The nutrient solution was prepared with following contents: Calcium Nitrate (SS1) 2.4 kg / 40 liter water, NPK (Kristalon 12:12:36 (SS2) 2.2kg /40 Liter water and Nitric acid (SS3) liter/50 liter. The total amount of SS1, SS2 and SS3 applied were 61.3 Kg, 94.6 Kg and 15Kg, respectively twice a day by measuring EC and pH of nutrient solution in the fertilizer tank which was circulated as closed system.. The plant protection of the crop was controlled by the specialists in the plant protection centre. Physical and chemical characteristics, number of fruits, fruit weight and total soluble solids percentage were recorded and collected data were statistically analyzed using Mstatc programs.

Results and Discussions

Yield components and yield:

Days to first harvest varied from 44 for Selected Tahriry and Camarosa to 53 for Chandler. Harvesting period continued for 86 days for Selected Tahriry and Camarosa while it was 77 days for Chandler variety. Selected Tahriry variety produced significantly ($p<0.05$) higher number of fruits (478/m2) as compared to other two varieties (Table 1). Significant differences were observed in average fruit weight and average yield (g) per plant between the varieties. Variety Selected Tahriry gave heaviest fruit weight (6.4 g) followed by Chandler (5.9 g). Average yield varied from 0.5 to 3.1 kg/m2 and highest yield was given by the variety Selected Tahriry (3.1 kg/m2) which was equivalent to 2.2 t/720 m2. The lowest yielding variety was Chandler (0.5kg/m2) that was equivalent to 0.33 t/720 m2 (Table1). The low yield in chandler was due to disease infestation.

Quality:

Percentage total soluble solids ranged from 7.0 to 8.2 without significant differences among the varieties. Variety Camarosa gave higher total soluble solids (8.2 %) whereas Selected Tahriry was the lowest (7.0 %). Selected Tahriry is round in shape with regard to fruit shape. Camarosa and Chandler are spherical. All the three varieties have malformation, whereas variety Tahriry had high malformation, medium for chandler and low for Camaroza (Table 2).

Table 1 . Mean of yield and yield components of three strawberry varieties grown using vertical system under Non- Cooled green hall at ARC during 2003/2004 season.

Varieties	Days to first harvest	Harvesting period	Average fruit number/m^2	Yield kg/m^2	Average fruit weight(g)	Yield t/720m^2
Selected Tahriry	44	86	478	3.1	6.4	2.2
Chandler	53	77	78	0.5	5.9	0.33
Camarosa	44	86	360	2.0	5.6	1.5

LSD at 0.05 39.3 0.36 0.8 2.9

Table 2. Physical and Chemical characters of three strawberry varieties grown using vertical system under Non- Cooled green hall at ARC during 2003/2004 season.

Varieties	Fruit Shape	Malformation	TSS %
Selected Tahriry	Round	High	7.0
Chandler	spherical	Medium	8.1
Camarosa	Spherical	Low	8.2

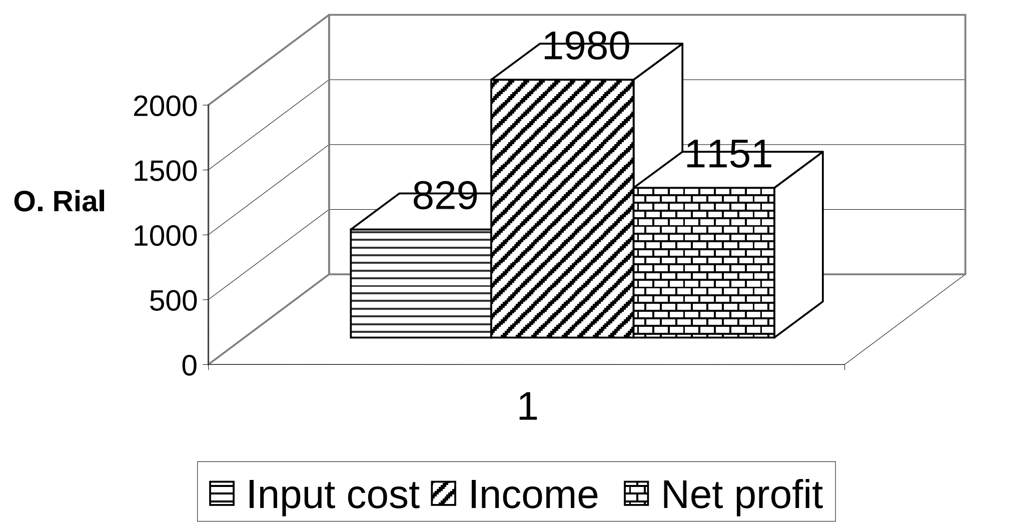

Fig.1 Input cost, Income and Net Profit of strawberry grown in hydroponics vertical system during 2003/04 season

Evaluation of cucumber (Cucumis sativus) production under cooled and non -cooled greenhouse conditions using soilless culture (sand media)

Muthir S.S Al Rawahy, Fatma M. Al Raisy, Salem M. Al Makhmmari, Dr. Ahmed albakry Eng. Khair albusaidi

Abstract

Two Cucumber varieties, Printo F1 and Hana F1 were planted to evaluate their performance in yield and quality attributes under cooled greenhouse and non- cooled greenhouse covered with insect proof net , respectively during 2003/2004 season at agricultural research centre (ARC) in a non replicated plot. The results revealed that although cooled greenhouse produced highest production (1.7 t/gh) than non-greenhouse (1.5 t/g), however the cost of production in it is high.

Introduction

Protected cultivation of vegetable cash crops especially cucumber has been widely distributed in the sultanate. The Ministry of Agriculture and Fisheries encouraged farmers to introduce greenhouses by subsidizing 50% of the price of the greenhouse. Numbers of greenhouses have reached to more than thousand. 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. 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. Moreover, due to the availability of favorable temperature cucumber can be grown during winter season (October – end of April) without using cooled greenhouse. This experiment was carried out to study the production of cucumber under non-cooled greenhouse conditions and compare it with cooled greenhouse production.

Materials and methods:

The experiment was conducted in a non cooled green house with an area of 270 m2 covered with white insect proof net 80 micron only and cooled greenhouse with same area. Seeds of cucumber varieties Hana F1 and Printo F1 were sown on 8 /1/04 and 19/12/04 , respectively and transplanted on 17/1/04 and 28/1/04 , respectively in a non replicated plots .Pure sand was used as a media filled in plastic bags for non-cooled and in five channels for cooled greenhouse .EC and pH of the sand were 0.6 ds/m and 7.5 respectively. Spacing between rows was 1.5m and spacing within the plants 50 cm. A drip irrigation system equipped with irrigation controller was used to irrigate the crops. Ready made soluble fertilizers of NPK (Kristalon 12-12-36) and Calcium Nitrate and magnesium sulfate were applied through irrigation system. The plant protection of the crop was controlled by the specialists in the plant protection centre. The crop was harvested twice a week. The cost of production inputs such as Water consumption (m3), electricity (Kw), fertilizers etc. during the course of the trials was calculated. Yield and yield components were recorded and statistically analyzed used MSTATC program.

Results and Discussions

Yield and yield components:

The data in table one presents yield and yield components of cucumber varieties produced in two greenhouses. The results revealed that days to first harvest were rather same for both greenhouses (31-32 days). In other side, the crop in non- cooled greenhouse was terminated earlier (102 days) than other one (153 days). Average yield of plant in cooled greenhouse rather highest than non-cooled (3.5 and 2.9 kg, respectively). The difference in yield /m2 between two greenhouses was 1.1 and yield t/270 m2 was 0.2 tons (Table 1). In general, there was no big difference in cucumber production between two greenhouses during that period.

Table 1: Yield and yield components of two cucumber varieties under cooled and non-cooled greenhouse conditions at agricultural research centre (ARC) during 2003/2004 season.

Yield components	Cooled greenhouse (270 (m^2)	Non-cooled greenhouse (270 m^2)
Days to first harvest	**31**	**32**
Harvesting period (days)	**122**	**70**
Total no. of fruits	**13423**	**12819**
Average yield/plant (kg)	**3.5**	**2.9**
Total yield/kg	**1744**	**1451.5**
Yield/(m^2)	**6.5**	**5.4**
Yield/270 (m^2)	**1.7**	**1.5**

Table 2: Economic analysis of cucumber production in Non cooled and Cooled greenhouse during 2003/04 Season

Items	Non cooled Greenhouse		Cooled Greenhouse	
	Greenhouses (270m^2)			
	Quantity	**Cost R.O**	**Quantity**	**Cost R.O**
No. of Seeds	**1000**	**50**	**1000**	**50**
Kristalon (NPK)	**35 kg**	**15**	**35 kg**	**15**
Calcium nitrate	**15 kg**	**3**	**15 kg**	**3**
Electricity	**0**	**0**		**35.19**
Water (m^3)	**40**	**30.8**	**40**	**30.8**
No. of labor	**1**	**135**	**1**	**135**
Input cost		**233**		**268.19**
Income		**450**		**510**
Net profit		**217**		**241**

Screening and evaluation of muskmelon (Cucumis melo) varieties under greenhouse conditions

Abstract

Five muskmelon melon varieties, Sophy, Big Star 2527, Regal F1 Niz-52-104 F1 and Aitana RZ F1 hyb were planted using soilless culture under greenhouse conditions during 2003/2004 season at agricultural research centre(ARC) to study their performance in yield and quality attributes. The results revealed significant ($p<0.05$) differences between the varieties in the percentage of female flowers, yield and yield components except total soluble solids percentage (TSS %). Sophy and Niz-52-104 F1 produced the highest number of fruits. Big star F1 produced the lowest number of fruits and yield. Average fruit weight ranged from 420-700 g for the tested varieties .Estimated yields were 291.6 kg / 270 m2 for Sophy and 262.1 kg /270 m2 for Niz-52-104 F1 varieties.

Introduction

Muskmelon (curcumas melo) is considered as one of the most important Cucurbitaceae crop in the Sultanate of Oman. Summer season (February – beginning of May) is the main season for the production of this crop in the open field; however, some farmers grow it as a winter crop because it has more demand during this period. There are many recommended varieties for open field .However, greenhouses varieties are limited .The aim of this investigation was to find a high yielding of muskmelon varieties for protected cultivations and extending of muskmelon production season by using controlled greenhouses .In addition to study the performance of these varieties in yield and quality attributes by using soilless culture technique.

Materials and Methods

The experiment was carried out in greenhouse of an area of 270 m2. The seeds were sown on 20/2/04 and transplanted on 29/2/04 in bags filled with pure sand. The experiment was laid in RCD with five replications. Spacing between irrigation lines was 1.5 m and within the plants was 50 cm. The plants were irrigated four times a day for one minute in each irrigation and the frequency was increased up to eight times according to need of plants. The plant protection of the crop was controlled by the specialists in the plant protection centre. Ready made soluble fertilizer NPK 12:12:36 (Krestalon), Calcium Nitrate and Magnesium Sulfate were applied through irrigation system. Three plant samples from each replication were determined to count number of male and female flowers. Total number of fruits, fruit weight, total soluble solids percentage, flesh thickness and vacuole thickness were measured and recorded .The data were statistically analyzed using Mstatc program.

Results and Discussion

Flowering features:

The data in table one presents flowering features of muskmelon varieties grown under greenhouse conditions. The results revealed obvious Significant differences ($p<0.05$) in percent of male and female flowers between the varieties. High female flower percentage was produced by the variety Big Star 2527 F1 (53.5%) followed by Regal F1 (41 %). While the variety Sophy F1 gave, the lowest female flower percentage (10.3%) followed by Niz 52-104 F1 (26.2 %).

Yield and yield components:

It was cleared from the results in table one that the fruit set in variety Sophy was high, although it produced lower female flowers followed by Niz 52- 104 F1 compared with Big Star F1. They produced higher number of fruits (17 fruits), while Big Star F1 produced the lowest three fruits. Significant differences in average fruit weight and yield (kg/270 m2) were recorded between the varieties. Average fruit weight ranged from 420 to700g. Variety Big Star F1 produced the heaviest fruit weights (700g) followed by the variety Sophy F1 (500 g). High fruit yield was produced by Sophy F1 (291.6 kg/270 m2) followed by Niz 52-104 F1 (262.1 kg/270 m2) and the lowest was produced by Big Star F1 (75.6kg/270 m2). Significant ($P<0.05$) differences were observed in flesh thickness and vacuole thickness between the varieties. Flesh and vacuole thickness ranged from 2.4-3.3 cm and 3.0-4.7 cm respectively. Variety Sophy F1 gave higher flesh thickness (3.3 cm), while Big Star F1 gave higher vacuole thickness (4.7 cm). No significant differences were observed in total soluble solids percentage between varieties, which ranged from 9.7 to 12.5 %.

Table 1: Flowering features of five muskmelon varieties grown in sand media under cooled greenhouse conditions during 2003/2004 season at ARC.

Varieties	No. of male flowers	No. of female flowers	Female flowers %
Sophy F1	70	8	10.3
Big Star F1	20	23	53.5
Regal F1	23	16	41.0
Niz 52- 104 F1	31	11	26.2
Aitana F1	26	16	38.1
LSD at 0.05	18.5	7.6	

Table 2: Yield and yield components of five muskmelon Varieties grown in sand media under cooled greenhouse conditions during season 2003/2004 at ARC.

Varieties	Skin thickness (cm)	Vacuole thickness (cm)	TotalNo. of fruits	AVG. fruit wt (g)	Yield kg/ 270 m^2	Yield t/ha	TSS%
Sophy F1	3.3	4.6	17	500	291.6	10.8	12.4
Big Star F1	2.4	4.7	3	700	75.6	2.8	12.5
Regal F1	3.1	4.1	7	450	118.8	4.4	10.7
Niz 52- 104 F1	2.7	4.5	17	440	262.1	9.7	10.4
Aitana F1	3.1	3.0	9	420	130.3	4.8	9.7
LSD at 0.05	0.4	0.5	6.5	110	120.3	4.5	NS

Evaluation of Growing Tomato (Lycopersicum esculantum) in Soilless Techniques (closed system) under Cooled Greenhouse conditions

Abstract

Two tomato varieties; Niz 63-308 F1 (fresh type) and Sun cherry F1 were planted using hydroponics system (closed system) to evaluate their performance in yield and quality attributes in a non replicated plot under greenhouse conditions during 2003 season at agricultural research centre (ARC). The fruit yield ranged from 1.8 t/gh for Niz 63-308 F1 (fresh type) and 1.4t/gh for Sun cherry F1. The productivity of squre meter for Niz 63-308 F1 was 6.7 kg and 5.3 kg for Suncherry F1

Introduction

Sultanate of Oman is located among arid and semi-arid regions which are characterize with harsh climatic conditions, especially high temperature, drought etc. There are two agriculture growing seasons in the Sultanate, winter season (September – January) and summer season (February – May). The maximum temperature reaches to more than 50 oc during summer season. So, most of vegetable crops are growing during the winter season, consequently this leaded to short growing season. One of the main targets for introducing protected cultivations was to extend the growing season of vegetable crops especially tomato. In last years, the problems of water and soil salinity and soil borne diseases have been raised especially in greenhouses due to intensive cultivation of these greenhouses. Soil-less technique in vegetable production is one of the efficient ways that are used in such circumstances particularly under protected agriculture. It depends on artificial soil media such as perlite and sand ect and it offers a way of improving water – use efficiency and obtaining better water and fertilizer management, in addition to it gives high yielding compared to the traditional way. The aim of this investigation was to evaluate the productivity of different tomato varieties in yield and quality attributes by using hydroponics techquies (closed system).

Materials and Methods

The seeds of two tomato varieties namely, Niz 63-308 F1 (Fresh type) Sun cherry F1 (Cherry type) were sown on 10/12/03 and transplanted on 10/1/04 in a non-replicated plot in hydroponics closed system. The greenhouse consisted of eight channels, each channel 14m long and 35cm width and the spacing between channels was 1.64 m and eithin plants 50 cm .The number of plants in each channel was 60 plants making 480 plants in eight channels. The plants were irrigated with nutrient solutions twice a day. The nutrient solution was prepared with following contents: Calcium Nitrate (SS1) 2.4 kg/40 liter water, NPK (Kristalon 12:12:36 (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 72 kg, 61.6 kg and 12 liter, respectively. The electrical conductivity (EC) and pH were monitored throughout the course of the experiment. The system was automatically connected by a timer working to stops every 15 min during the day and every one-hour during the night. The specialists in the plant protection centre controlled the plant protection of the crop. Three plants from each replication were determined as sample for measuring the plant height, number of inflorescence and number of flowers per inflorescence every two weeks. The number of fruits and the fruit weight were recorded. Five fruits from each replication were used to measure total soluble solids percentage. The data were recorded and statistically analyzed used MSTATC program.

Results and Discussion

Flowering characteristics:

Table 1 presents the flowering features of two evaluated tomato varieties. The nature of flowering in Sun cherry variety was in uniformed clusters compared with other variety that the fruits overlapped. The number of inflorances per plant was eight for Niz variety and 10 for Sun cherry F1.Total number of flowers per plant was 51 for Niz 63-308 F1 and 179 for Sun cherry F1.

Yield and yield components:

The data in table 1 presents yield and yield components of tested tomato varieties under hydroponics. Days to first harvest ranged from 67 for sun cheery F1 and 73 for Niz 63-308 F1 (fresh type). Picking period continued for 68 days for sun cherry and 61 days for Niz 63-308 F1 variety. Number of fruits /m2 was 106 for Niz 63-308 F1 (fresh type) and 472 for Sun cherry F1 (Cherry type). The yield varied from 1.4 t/gh for the Sun cherry tomato and 1.8 t/gh for Niz 63-308 F1. Total soluble solids percentage was 4.9 % for Niz 63- 308 F1 and 6.6 for Sun cherry F1.

Table 1: Yield and yield components of two tomato varieties grown in hydroponics (closed system) under cooled greenhouse during 2003/2004 season at ARC.

Varieties	Days to first harvest	Average no. of inflo./plant	Total no.of flower/plants	No .of fruits/m^2	Yield kg/m^2	Yield t/gh	Yield t/ha	TSS%
Niz 63-308 F1	73	8	51	106	6.7	1.8	66.9	4.9
Sun Cherry F1	67	10	179	472	5.3	1.4	53.1	6.6