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Development of lentil germplasm for rainfed areas in Egypt

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SUMMARY – A new lentil (*Lens culinaris* Medikus) cultivar, developed in north Sinai and named Sinai 1, showed high adaptability to dry conditions and yielded 116% higher than the local cultivar Giza 9. This cultivar matures one month earlier and has good seed quality. The farmers in the Sinai have greatly accepted this new cultivar. In addition, there are some other lentil genotypes that are promising for rainfed areas in Egypt.

Key words: Lentil, rainfed, North Sinai, Sinai 1.

RÉSUMÉ – *"Développement de germoplasme de lentilles pour les zones non irriguées en Egypte". Un nouveau cultivar de lentille (*Lens culinaris *Medikus) développé au Nord du Sinaï et dénommé Sinaï 1, a montré une grande adaptabilité aux conditions arides et a eu un rendement de 116% plus élevé que le cultivar local Giza 9. Ce cultivar mûrit un mois plus tôt et présente une bonne qualité de la semence. Les agriculteurs du Sinaï ont très bien accepté ce nouveau cultivar. En outre, il y a quelques autres génotypes de lentilles qui sont prometteurs pour les zones pluviales en Egypte.*

Mots-clés : *Lentille, non irrigué, Nord du Sinaï, Sinaï 1.*

Introduction

The rainfed narrow coast in north Egypt extends from Rafah to the east to Saloum in the west. It is 500 km long and 10-20 km wide. Rainfall in this region is extremely low and ranges from 200-300 mm in Rafah to about 105 mm in Saloum. Because this region is classified as dry environment, drought-tolerant crop genotypes should be available to the farmers so that agriculture is more sustainable.

Lentil is a suitable crop to be grown in such areas due to its low water requirements, in addition to its high nutritional value for both humans and animals (Nordblom and Halimeh, 1982), and its important role in nitrogen fixation and improving soil fertility and properties. Lentil has been recently grown in this region where only 161 feddans (68 ha) were planted in 1989 in North Sinai. Its area has increased gradually and reached 2525 feddans (1060 ha) in 1995 (Anonymous, 1996). However, the cultivated area in this region fluctuates according to the amount of rain received every season. The major constraints that affect crop production under low-rainfed conditions in the north coastal region of Egypt may be summarized as follows: (i) low average rainfall and difficulty to predict the amount and timing of rain; (ii) poor soil fertility with low soil content of organic matter; (iii) the majority of the soil is loose sand, which has poor water-holding capacity; (iv) most farmers use a mono-culture system, they use a cereal-cereal crop system and do not use a cereal-legume crop rotation system; (v) overgrazing is common, which does not help to accumulate plant residue in the soil and hence does not build up soil organic matter; and (vi) soil erosion by wind is common in these areas and reduces soil fertility.

The Agricultural Research Center (ARC) and many other research institutes in Egypt are making efforts to solve the constraints mentioned above. In the present paper, the efforts made by the Food Legume Program at ARC, related to the development of new lentil cultivars adapted to low rainfed conditions in north coast region of Egypt, are highlighted. The lentil program in rainfed areas in North Sinai was established in the 1993-94 season (Hamdi, 1998). The main objective of this program are to: (i) evaluate lentil germplasm, landraces and introductions for their yield potential under rainfed conditions; (ii) evaluate the new lentil cultivar Sinai 1 in pilot-production demonstration plots, compared with the widespread local cultivar Giza 9; and (iii) create an extension program for the extension specialist and farmers in North Sinai to advise them of the improved lentil production package and recommendation in rainfed areas.

Materials and methods

Evaluation of yield potential of Sinai 1

Sinai 1 was grown in large pilot demonstration plots using a simple practical package including plant population of 250 plants/m^2 with *Rhizobium* inoculation (400 g product/fed). For comparison, the local cultivar Giza 9 was grown next to Sinai 1 in equal areas at each site, but with 150 plants/m^2 and without *Rhizobium* inoculation (as the farmers' practice). The plots were planted in four successive winter seasons (1993-97) in Rafah (North Sinai) and Matrouh (the Northwest Coast). Sowing was done on 10-20 November every season. Rainfall was the only source of water, and no fertilizer or any supplemental irrigation was added. The first season was extremely dry with only 70 mm rain; hence the trials were cancelled. Rainfall in the other seasons was 180, 99.4, and 211 mm, respectively.

Evaluation and identification of new lentil lines adapted to low-rainfed conditions in the North Coast of Egypt

Evaluation of 15 lentil lines of Lentil Regional Yield Trial for Drought Tolerance (LRYT-DT) was made in North Sinai in 1994-95, 1995-96, and 1996-97 seasons. The trials were grown in Rafah at two sites in each of the first two seasons and one trial in the third season. Planting was done during the first half of November every season, in plots (18 m^2/plot) consisting of 6 rows, 4 m long and 0.3 m apart, in a randomized complete block design with 4 replicates. In addition, 33 new exotic lentil lines from the Lentil International Screening Nursery for Drought Tolerance (LISN-DT), introduced from ICARDA, were evaluated in two seasons: 1995-96 and 1996-97 in North Sinai. Planting was done on 12 November 1995 and 5 December 1996. Sowing was in single-row plots, 4 m long, 0.3 m apart in a randomized complete block design with 2 replicates. Statistical analysis of variance and calculation of Least Significant Differences was made according to Gomez and Gomez (1984).

Results and discussion

Evaluation of yield potential of Sinai 1

The new cultivar Sinai 1 is derived from a bulk selection from the Argentinean cultivar Precoz' made in north Sinai in 1994. It is highly adapted to low-rainfed conditions in the North Coast of Egypt (Hamdi *et al.,* 2003). The cultivar is classified as very early in maturity (earlier than Giza 9 by 15-29 days). It is planted in the second half of November, while harvesting is in early March at the termination of rainfall. The cultivar is large seeded (1000-seed weight = 40-45 g), the cotyledons and seed coat are yellow, and it is resistant to root-rot disease (Hamdi *et al.,* 2003).

In the 1994-95 season, only 9 sites were harvested from a total of 15 sites planted (Table 1). There was wide variability in site yield. For example, site number 4 gave seed yield of 0.8 ardab/fed (305 kg/ha), while site 9 produced 6.6 ardab/fed (2515 kg/ha) for Sinai 1. Site variability in seed yield may be due to the variation in site rainfall rate, water holding and soil fertility that varied widely between sites. In the second season (1995-96), rainfall was much lower than in the first year, with an average seasonal rainfall of 99 mm in Rafah and 83 mm in Matrouh. Hence, only 6 sites out of 20 were harvested, 4 sites in Rafah and 2 in Matrouh (Table 2). The third season (1996-97) was wetter than the last two in North Sinai only, where the seasonal rainfall was 211 mm. In Matrouh the season was very dry; thus the program was cancelled. In Rafah, Sinai 1 gave an average seed yield of 5.9 ardab/fed (2248 kg/ha), while seed yield of Giza 9 was 3.8 ardab/fed (1448 kg/ha) (Table 3).

The three years' results confirmed the superiority of Sinai 1 in both seed and straw yields. It exceeded Giza 9 in seed yield by 52, 243 and 55% in the 1994-95, 1995-96, 1996-97 seasons, respectively. The results also showed a wide variation between seasons in harvest index (Table 4), in the two wet seasons of 1994-95 (180 mm rainfall) and 1996-97 (211 mm), seasons, respectively. The results showed also a wide variation between seasons in harvest index (Table 4). In the two wet seasons of 1994-95 (180 mm rainfall) and 1996-97 (211 mm), harvest index was high, with an average of 0.51 and 0.43 for Sinai 1 and 0.37 and 0.37 for Giza 9, respectively. In the dry season of 1995-96 (99 mm), harvest index was low, with an average of 0.19 for Sinai 1 and 0.07 for Giza 9.

Table 1. Seed yield, straw yield and plant height for the new cultivar Sinai 1 compared to Giza 9 grown under rainfed conditions in 9 sites in North Sinai (Rafah) in 1994-95†

Site Farmer's name	Seed yield (ardab/fed)††		Straw yield (kg/fed)		Plant height (cm)	
	Sinai 1	Giza 9	Sinai 1	Giza 9	Sinai 1	Giza 9
Al-tameer	1.9	1.0	899	927	22.8	16.3
Soilam	5.8	1.4	1311	580	14.0	7.8
Khalil	1.0	1.7	430	929	12.3	11.0
Moneer	0.8	0.7	903	710	5.0	2.5
Soliman(1)	1.6	1.1	282	773	10.0	6.0
Zoarob	2.4	1.6	1008	819	20.0	14.0
Khamis	1.8	1.3	1076	702	12.8	9.5
Soliman(2)	2.9	2.9	–	–	11.8	7.3
Salem	6.6	4.5	–	–	23.8	15.8
Mean	2.7	1.8	840	777	14.7	10.0

†Rainfall = 180 mm.
††One ardab = 160 kg; fed = 0.42 ha.

Table 2. Seed and straw yields of the new cultivar Sinai 1 compared to Giza 9 grown under rainfed conditions in North Sinai (Rafah) and Northwest Coast (Matrouh), 1995-96†

Site Farmer's name	Seed yield (ardab/fed)††		Straw yield (kg/fed)	
	Sinai 1	Giza 9	Sinai 1	Giza 9
North Sinai				
Saied	2.2	0.2	2202	1529
Salem	3.7	1.0	2252	1513
Khamis	0.5	0.2	1361	958
Auda	3.2	1.6	2353	2168
Mean	2.4	0.7	2042	1542
Matrouh				
Breha	1.3	0.6	1378	874
Eldow	1.0	0.4	1412	504
Mean	1.1	0.5	1395	689
Over all mean	1.8	0.6	1719	1116

†Rainfall = 99.4 mm.
††One ardab = 160 kg; fed = 0.42 ha.

Table 3. Seed and straw yields of the new cultivar Sinai 1 compared to Giza 9 grown under rainfed conditions in North Sinai (Rafah), 1996-97†

Site Farmer's name	Seed yield (ardab/fed)††		Straw yield (kg/fed)	
	Sinai 1	Giza 9	Sinai 1	Giza 9
Mousa Abou Ketaif	5.4	3.8	2122	1807
Soliman Ahmed	5.9	3.5	2120	1576
Auda Al-Sharookh	4.5	2.9	1282	588
Gharby soliman	9.7	5.3	2479	1849
Auda Saied	7.9	5.7	2353	1681
Khamis fares	5.0	4.5	2815	1975
Saleh Al-harun	2.2	2.0	1933	1429
Fergan Abou Melah	6.7	2.6	2668	2101
Mean	5.9	3.8	2222	1626

†Rainfall = 211 mm.
††One ardab = 160 kg; fed = 0.42 ha.

Table 4. Harvest index of the new cultivar Sinai 1 compared to Giza 9 grown under rainfed conditions in North Sinai in three seasons

Season	Sinai 1	Giza 9	Seed yield increase of Sinai 1 over Giza 9 (%)	Rainfall (mm)
1994-95	0.51	0.37	50	180
1995-96	0.17	0.09	243	99.4
1996-97	0.43	0.37	55	211

Evaluation and identification of new lentil lines adapted to low-rainfed conditions in the North Coast of Egypt

For LRYT-DT, the results showed significant differences among entries every season (Table 5). There was also a variation between seasons in seed yield, which may be due to the variation in seasonal rainfall. Overall, the highest-yielding lines in descending order were FLIP 86-7L, FLIP 84-112L, Giza 4, XG 81-5, Sinai 1, and Giza 370; all exceeded Giza 9. For LISN-DT, the results also showed wide variation between seasons in seed yield. The average seed yield in the first season was 1.5 ardab/fed (572 kg/ha) and 0.9 ardab/fed (343 kg/ha) in the second season (Table 6). Despite the fact that rainfall in 1996-97 was higher than in 1995-96, seed yield of 1996-97 was lower. This was probably due to late planting in 1996-97, moreover that an amount of rainfall of 25 mm was received early in October, then there was no rain after planting for a month. Therefore, plant growth and production were affected hence yield was reduced. Seed yield of some lines varied from one season to another; however, the two lines FLIP 86-51L and FLIP 91-1L were the most stable and most promising.

Table 5. Seed yield, straw yield, and percentage of germination for lentil lines in the Lentil Regional Yield Trial, Drought Tolerance (LRYT-DT) grown in North Sinai in 1994-95, 1995-96, 1996-97 seasons

Line	Seed yield (ardab/fed)†			Straw yield (kg/fed)			Germ. (%)
	1994-95	1995-96	1996-97	1994-95	1995-96	1996-97	
L138	3.00	1.39	0.62	–	1996	682	85
L318	2.85	0.76	1.20	–	1807	1068	86
ILL 3490	2.93	0.76	2.03	–	2114	1029	89
ILL 3693	–	1.18	1.41	–	1916	777	88
FLIP 84-51L	2.38	–	1.50	1426	–	1019	86
FLIP 84-112L	2.61	–	1.88	1539	–	1122	85
FLIP 86-7L	–	2.31	2.23	–	2555	1194	91
FLIP 89-60L	–	–	1.46	–	–	933	83
XG 81-5	3.63	0.84	2.11	1527	2059	945	89
X84 s-48	2.63	1.18	1.02	–	2021	677	85
Giza 4	3.74	0.68	2.23	1640	1882	1112	91
Giza 9	2.67	0.96	1.04	1521	2076	650	93
Giza 370	3.33	1.05	1.79	–	1975	1003	88
Fam. 29	2.73	0.81	1.69	–	1866	1175	86
Sinai 1	2.94	1.08	2.49	1210	1975	769	86
L.S.D. 0.5%	1.10	0.63	1.00	NS	500	371	78
No. of trials	2	2	1	2	2	1	

†One ardab = 160 kg; fed = 0.42 ha.

It may be concluded that the development of lentil lines adapted to the conditions in the North Coast of Egypt is essential for sustainability of lentil planting in this region. In this regard, breeding, selection and evaluation of any materials should be done under rainfed conditions in the North Coast of Egypt. Development of the new cultivar Sinai 1 is a good example; it performed well in dry conditions, and

farmers in North Sinai greatly accepted it. A seed amount of 1.5 tons of Sinai 1 was planted in North Sinai in 1997-98 season according to the farmers' request. The present work also indicated that there are several promising lentils lines which showed high yield and good stability performance. The final evaluation of those lines has been undertaken, and some of them will be released soon. The sustainability of agriculture in rainfed areas in Egypt is threatened due to the constraints mentioned above. Therefore, more emphasis is needed to solve the existing constraints, especially those related to increasing the efficiency of soil-water holding capacity, increasing soil content of organic matter, role of crop residues in improving soil properties and organic matter content.

Table 6. Seed yield, straw yield and percentage of germination for exotic lentil lines of the International Screening Nurseries, Drought Tolerance (LISN-DT) grown in North Sinai, 1995-96 and 1996-97 seasons

Line	Seed yield (ardab/fed)†		Straw yield (kg/fed)		Germ. (%)
	1995-96	1996-97	1995-96	1996-97	
FLIP 86-51L	1.83	1.31	198	281	85
FLIP 89-31L	1.43	0.44	1130	280	83
FLIP 89-58L	1.83	0.73	2098	234	83
FLIP 89-60L	1.89	0.95	936	198	85
FLIP 91-1L	1.44	1.02	1293	245	78
87519	1.62	1.39	1340	350	88
86591	1.55	0.95	1352	198	88
FLIP 92-46L	1.40	0.58	2129	257	83
FLIP 92-48L	1.20	0.95	1442	374	78
FLIP 92-50L	0.98	0.88	1454	327	85
FLIP 95-1L	1.69	0.80	955	280	80
FLIP 95-2L	0.85	0.66	1482	245	88
FLIP 95-3L	1.15	0.58	1636	245	85
FLIP 95-4L	0.83	0.58	969	257	83
FLIP 95-5L	1.61	0.37	1415	234	75
FLIP 95-6L	1.28	1.02	1914	234	90
FLIP 95-7L	1.71	0.80	1137	303	88
FLIP 95-8L	0.64	0.44	1676	164	75
FLIP 95-61L	1.87	0.66	2089	303	95
FLIP 95-63L	–	0.51	–	280	60
FLIP 95-64L	–	0.88	–	326	83
FLIP 96-46L	–	0.51	–	210	85
FLIP 96-49L	–	1.31	–	315	85
FLIP 96-53L	1.01	1.02	1064	198	85
FLIP 96-54L	3.12	0.95	1993	245	73
FLIP 96-55L	2.04	0.85	1657	269	90
FLIP 96-56L	1.74	1.30	2652	257	90
FLIP 96-57L	1.33	1.10	1492	338	85
FLIP 96-58L	0.76	0.66	1261	303	88
FLIP 96-59L	0.38	1.90	1573	339	93
FLIP 97-33L	–	1.02	–	303	90
FLIP 97-35L	–	0.88	–	210	90
Giza 9	1.28	0.95	1989	257	80
L.S.D. 0.5%	1.74	0.57	1275	157	21.6
Mean	1.51	0.88	1494	269	84

†One ardab = 160 kg; fed = 0.42 ha.

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