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Combat Degradation in Rain Fed Areas by Introducing New Drought Tolerant Crops in Egypt

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Abstract: The Northern Coastal Region of Egypt is unique in its strategic, historical and environmental background. This region includes rain fed areas located in northern part of Sinai Peninsula. In Sinai Peninsula, the average rainfall decreases from North-East to the South-West. Degradation and Desertification threaten these areas and it is necessary to adopt innovative approaches to the use and management of such fragile resources. The major constraints which threaten sustainability in this area are disappearance of crop rotation due to cereal continuous (barley) and overgrazing in range lands, inadequacy of rain-fall in quantity and distribution, poor soil fertility, low crop productivity and wind erosion. Agriculture in these areas is highly correlated with rainfall therefore; plantations and horticultural crops cover only 10 km from the sea towards the South where rainfall ranged from 150 to 250mm/yr along the Mediterranean Sea starting from Rafah in the east to the Libyan borders in the West. The next 10 km towards the desert are very poor rangelands. Agricultural Development and Crop Intensification Research Project did effort to combat desertification through innovating cropping patterns in these areas by the introduction of some new crops tolerant in nature to drought, very pertinent to the Bedouin diet and their livestock. The project program included the introduction of Cassava and Quinoa crops In Sinai. To obtain optimum recommendation package to introduce cassava and quinoa in desert lands of Egypt. Cassava trials includes varietal responses to our environment which indicated superiority of Brazilian CV 1 over Indonesian CV K2. Cassava tuber and forage yield were the highest when stakes were planted at mid of April rather than the early planting (first of April) or late planting (first of May). Nutritional field trial revealed gradual increases in cassava tuber yield up to the heaviest 46.5Kg P_2O_5 and 72Kg of K_2O, respectively. The data indicate that there were decreases in HCN concentration in tuber tissue with increasing phosphorus or potassium up to the heaviest. Intercropping cassava with Nigerian cowpea achieved yield advantage by 71% more than growing cassava as solid. Quinoa also proved success in desert lands. Thirteen varieties were tested under two types of land preparation (till and no-till systems). Two short day varieties under no-till system were superior. In North-West Coastal plains (Matrooh Exp. Stn.), quinoa with one supplementary irrigation yielded better than under rainfall only (rainfall rate ranged from 100-150 mm/yr). seeding on flat gave more yield than on ridges. The yield of quinoa significantly increased with diminishing plant spacing from 20 to 15cm. there were also gradual reduction in seed yield/fed with delaying time of seeding starting from mid of November till mid of February. Reduction between the first and latter date was estimated to 60%.

Key words: Cassava • Quinoa • Drought tolerant • Rain fed

INTRODUCTION

The greatest service which can be rendered any country is to add a useful plant to its culture. However, new crops are not a panacea, but, they have made major contributions to societies. New crops development is complex, risky, long term and usually surplus crops drive down market prices [1]. In the absence of sufficient profitable new crop alternatives, farmers are forced from the land. Large percents of the Egyptian farmers were displaced during last century. On other hand, recently, interest in new crops has intensified as a result of a number of interesting forcers. Plant disease epidemics and the worldwide loss of biological diversity have been responsible for an upsurge of interest in germ plasm diversity. Over much of last fifth decades,

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low prices, misdirecting prices for major commodities punctuated by brief periods of prosperity have rekindled among growers old concerns about profitable crop alternatives [2,3].

However in Egypt the five devenities; wheat and berseem in winter, rice, maize and cotton in summer dominates over 90% of the cultivated areas in the old lands. Berseem competes with wheat. Full season berseem competes with cotton. Wheat competes with cotton and rice competes with both cotton and maize. The struggle leaves no any opportunity for the inclusion of any new crops. Soybean, sunflower and canola acrages gradually diminished and became with minute importance in the old lands, whereas the new reclaimed land became the alternative and the only solution. The continued strength of the environmental movement has spurred interest in a more sustainable and diversified agriculture in Egypt while consumer demand for new foods and products has increased as a result of changing demography and health concerns. Finally economic forces continue to attract innovators and entrepreneurs who see potential in new crops and products [4].

The importance of integrating cassava and quinoa as new crops in the Egyptian cropping structure are: 1) Both cassava and quinoa offer alternative means of increasing farm income by diversifying products, hedging risks, expanding markets, increasing exports, decreasing imports, improving human and livestock diets and creating new industries based on renewable agricultural resources. 2) Both crops also can spar economic development in rural areas by creating local rural based industries, such as processing and packing and by providing general economic stability. 3) Both crops represent potential resources of new human foods and livestock feeds with increased digestibility and decreased antidietary factors. 4) Quinoa as a medicinal crop could assist in the battle with diseases such as cancer and acquired immunodeficiency syndrome (AIDS). 5) One of the major benefits of diversifications with new crops is income stability in the face of low prices due to oversupply of a single commodity [3].

Series of studies were conducted on cassava and quinoa, hopefully, towards the inclusion of these new crops to innovate the crop structure of desert area of Egypt. Quinoa (*Chenopodium quinoa*) seemed to be very pertinent to grow in the Egyptian desert and new reclaimed sandy soil combat degradation and diversification.

Cassava (*Manihot esculenta*)

Objective and Justifications: Cassava can be grown profitably in Egypt on soils of low fertility. The crop is a low cost production and is one of the cheapest foods. The crop is low labour requirements and easy to cultivate. Cassava can substitute wheat with a ratio of 30% cassava flour used in bread. The crop also can substitute maize with a ratio of 20-25% of the dried cassava chips used in animal feed. Cassava has the ability to grow on already depleted soil. Moreover, cassava cultivation in traditional agriculture is with no applied fertilizers vast dried area in North Sinai, North West Coast and Toshky region near Nasr Lake needs integration of production of both staple and forage crops to feed animal as well as for human food. Enriching animal feed by both dried leaves and roots of cassava is an important target. The success of reaching a balanced and economic mixture of dried cassava leaves, its root chips and wheat straw will solve an important problem in livestock feeding. In the dried areas cassava is a main component of Bledine; an easily digestible children food mixed with rice, sugar and edible oils. It can be also used bakery, in paper manufacture, hardening textile, pans and biscuits, bear and alcoholic products.

Pertinency for the Egyptian Environment: Cassava is tropic, drought tolerant and its water requirement does exceed 250 mm/yr. The crop tolerates long duration drought and severe wind storm. Cassava plants when exposed to long drought defoliate, but regenerate its vegetation growth very fast when conditions improve. The crop is very pertinent to grow where clover the main fodder crop can hardly grow under the extreme weather condition in deserts and the new reclaimed sandy soil in rainfed and areas around Nasr Lake. The crop can be grown successfully for human food (the tubers) or for as forage for sheep and camels and livestock.

Cassava experiments

Intercropping Cassava with Nigerian Cowpea under Different Fertilizer Rates in Sandy Soil

Methodology: Two field trials were conducted in two successive seasons in Ismaellia Research Station representing sandy soil of the Egyptian deserts to study the effect of some rates of phosphorus and potassium [15.5, 31 and 46.5 kg P_2O_5/fed] in the form of potassium sulphate. Cassava was grown as solid or intercropped with Nigerian cowpea. The treatments were assigned randomly in three replications in complete randomized block system. The plot area was 42m^2. Intra row spacing was 100cm for cassava and 20cm for cowpea. The data was subjected to combined analysis according [5].

Cassava stalks were cut into cutting each of 25-30 in length and planted at 26th of March in the first season and at 21th of March in the second season. The stalks were planted vertically by inserting two thirds of them above the ground. All treatments were irrigated immediately after planting and irrigated routinely at four days intervals during the first month of the early summer season and as needed during late summer season. Nigerian Cowpea was sown on the 14th of May and 9th of May in the two successive seasons.

Determinations included yield and yield components and HCN concentration in tuber tissues which determine quality of cassava.

RESULTS AND DISCUSSION

Date in (Table 1) indicate clearly that the total number of marketable tuber/plant significantly increased with increasing phosphorus or potassium fertilizer up to the heaviest rate. The effect on the average length and diameter of marketable tuber per plant, the average weight of tuber/plant and the total fresh yield of tuber/fed behaved the same trend. It seemed that the increases in yield with increasing the rate of both fertilizers was as a result of the combined effect of yield components. These results were in accordance with those obtained by [6-9]. The data also indicate that solid planting was superior to the intercropping cassava. All values of pure stand cassava were higher than those of the intercropped (Table 2). Moreover, significant differences were indicated in case of number and weight of marketable tuber per plant and yield of fresh tuber/fadden. [10,11] came to similar results.

Data indicate in (Table 2) that intercropping achieved yield advantage by 71% more than growing cassava or cowpea either in solid state. The relative crowding coefficient which considers the ratio of each component in the intercrop had the same trend.

The data also in (Table 3) indicate that there were decreases in HCN concentration in tuber tissue with increasing phosphorus or potassium fertilizer up to the heaviest. Further, it is evident that highest values were observed 10 hours after harvesting. It is also evident that intercropping significantly increased HCN concentrations in the cassava tuber. Khalil [9], Payne and Webster [12] and Atalla *et al*. [13] supported the trend obtained on hydrocyanic concentrations.

Table 1: The effect of phosphorus, potassium fertilizer and intercropping cassava with Nigerian Cowpea on yield and yield components (Averages of two seasons)

	Traits				
Treatment	No. of marketable tuber/plant	Average length of M. tuber/cm	Average diameter of M. tuber/cm	Average weight of fresh tuber/plant	Yield Fresh tuber/fed.
Phosphorus F.					
P_2O_5 kg/fed					
15.5	3.31	3737	3.12	3.07	11.05
31.0	4.54	38.14	3.31	3.74	13.45
46.5	5.46	40.55	3.61	4.14	14.51
L.S.D. at 5%	0.35	2.02	0.12	0.28	2.80
Potassium F.					
K_2O kg/fed					
24	3.74	38.10	3.53	2.92	10.50
48	4.31	38.60	3.59	3.55	12.37
72	5.07	39.30	3.76	4.48	16.14
L.S.D at 5%	0.35	-	0.11	0.28	2.80
Intercropping system					
1:2	4.22	38.63	3.59	3.42	12.05
Pure stand	4.53	38.74	3.66	3.88	13.95
L.S.D. at 5%	0.29	-	-	0.23	2.29

Table 2: Land Equivalent Ratio and the Relative Crowding Coefficient (Average of two seasons)

	Relative Yield (RY)(1)			
System	$RY_{Cassava}$	RY_{Cowpea}	Land Equivalent Ratio (LER)(2)	Relative Crowding Coefficient (RCC)(3)
Cassava: Cowpea				
1: 2	0.86	0.85	1.71	56.98

N.B. (1) Relative yield (RY): Yield of the intercrop A or B/ yield of pure stand A or B

(2) LER= $RY_a + RY_b = \pm 1$ (if +1= achieved yield advantage and if-1 = yield loss).

(3) ±RCC= consider ratio of each component in the previous equation.

Table 3: Hydrocyanic acid concentration in fresh tubers at different periods starting from harvesting (averages of two seasons)

	HCN%(1) in fresh tuber tissues		
Fertilizer rate	After harvest	After 10hr	After one week
P2O5 kg/fed			
15.5	56.12	781.75	37.25
31.0	44.67		30.28
46.5	38.58	601.83	19.58
L.S.D. at 5%	2.28	19.77	2.18
K2O kg/fed			
24	50.44	664.75	42.47
48	46.05	562.67	24.15
72	42.87	449.92	20.49
L.S.D. at 5%	2028	19.77	2.18
Intercropping system	Fresh	After 10 hours	After 7 days
1: 2			
control	48.394	11.000	32.544
	44.511	507.222	25.528
L.S.D. at 10%	1.864	16.14	1.781

N.B. (1) HCN < 75 ppm (Sweet varieties), 75-125 ppm (Moderate) and > 250 ppm (Unadvisable).

Effect of Date of Planting on Growth and Yield of Some Cassava Varieties

Methodology: Two field trials were conducted in two successive seasons to study the effect of the date of planting cassava on the growth, yield and yield components in Toshky region around Naser Lake at the High Dam of Aswan. Cassava stakes were planted on the first of October, first of November and mid of March and Mid of April. Cassava Brazilian CV.1 and Indonesian CV.K11 were tested. The eight treatments were arranged in complete randomized block system and replicated three times. Plot area was 42m^2. Cassavas inter and intra spacing were at (1x1m). Data were statistically subjected to combined analysis according [5].

RESULTS AND DISCUSSION

Data presented in (Table 4) were confined only to the third and fourth dates, since, first and second date failed to survive and/or to grow normally. Data indicate that varietal response of plant height was not regular and no definite trend could be detected. On other hand, third date had more stimulating effect as compared with the fourth date. Data on the average number of the third date of planting were relatively higher than those of the fourth date. The values of yield component obtained of Brazilian cv.1 were also relatively higher than that of the Indonesian cv.kII. Data on the yield of fresh tuba/fed. indicate that cassava grown in the third date out-yielded that cassava grown in the fourth date. Varietal response was also regular and the Brazilian cv.I out-yield the Indonesian cv.kII in both the third and fourth planting date. [14] and [15] supported these results. They reported increases in yield with delaying planting the stakes till the spring season.

Quinoa (*Chenopodum quinoa*)

Objective and Justifications: Quinoa is an annual, broad leaved, dicotyledonous herb usually standing about 1-2 m high. Leaves come in average of colors, vary from white, yellow, pink to darker red, purple and black. Quinoa seeds are small (2.4mm), circular and flattened on two surfaces. Quinoa seed is pseudo cereal grain about 1.0 mm thick which range in diameter from 1-2.5 mm and seed weight from 1.4 to 4.3 g/1000 seed. The seeds come with same colors as the leaves. Quinoa grows in field with plant population density at a range from 100-120 thousand plants/acre. Quinoa seed yield ranges between 0.5-1.5 ton/acre. One of the important characteristic is that the crop is drought tolerant with a water requirement of not more than 400m/year. Therefore, it can be grown successfully with barley requirement of water. The crop can substitute wheat with a ratio of 40% quinoa flour used in bread, in addition, improving loaf taste. Quinoa has an exceptionally nutrition balance of protein, fat, oil and starch. The embryo takes up a greater proportion of seed than in normal cereals, so the protein content is high. Grains average 16-23 % protein more than twice the level in common cereal grains. Moreover, the protein is of usually high quality and is extremely close to the FAO standard for human nutrition.

Table 4: Effect of date of planting on growth and yield of some cassava varieties (average of two seasons)

Treatment		Plant height (cm)	Main stem (primary)	Secondary branches	Average of tuber/plant	Yield of fresh tuber (ton/fed)
Third date	Brazilian I	220	2.2	21.0	9.90	10.0
(1 March)	Indonesian kII	230	3.0	13.0	9.60	9.50
Mean		225	2.5	17.0	9.75	9.75
Fourth date	Brazilian I	210	4.0	9.0	9.10	9.25
(1 April)	Indonesian kII	190	40	10.0	8.50	8.70
Mean		200	4.0	9.5	8.8	8.98
L.S.D. at 5% for interaction		-	-	3.5	0.89	0.67

Quinoa grain are traditionally toasted or ground into flour. They can also be boiled, added to soaps, made into breakfast food or pastas and even fermented into beer. Quinoa flours, flakes, tortillas, pancakes and puffed grains are produced commercially. The plant is sometimes grown as a green vegetable. Its leaves are eaten fresh or cooked. Leaves and stakes are also used as an animal feed (for lamas, alpacas, donkeys, sheep and pigs). The grain and leaves are excellent feeds for swine and poultry. The seeds contain 5-8% oil; edible for human being. Quinoa oil has characteristic equal to that of corn.

Pertinency for the Egyptian environment: The plant is highly variable. Quinoa shows various photoperiod responses; from short day to no response. Rainfall conditions vary greatly with variety and country of origin. The crop is notable for its drought tolerance, especially during late growth and seed maturation, Quinoa tolerates a wide range of temperatures. Quinoa is a cool crop. The plant is normally unaffected by high frost (1c°) at any stage of development, except during flowering. The plant tolerates high temperature above 35°c but at higher temperature fail to produce seed in some countries.

The crop is newly introduced to Egypt and need extensive studies to optimize its cultural practice and adapting suitable varieties and promoting harvesting and post harvesting processes and manufacture of the crop.

Quinoa Experiments

Varietal Response of Quinoa to Land Preparation Method in Sandy Soil

Methodology: Thirteen varieties and strains were tested in deserts of South Sinai governorate (near Nuwaiba city). Three varieties were introduced from the Royal Agricultural University in Denmark while the other ten strains were from Peru. These varieties and strains were exposed to different method of land preparation. All the tested varieties were grown on no till system where they were also grown on ploughed soil. The 26 treatments were arranged in a split plot design with three replications.

Land preparation system occupied the main plots, whereas, Quinoa varieties and strains occupied the subplot. Subplot area was 42 m^2. Seeds of quinoa of different varieties were sown by mid of December by drilling method in rows 30 cm. apart. After germinating and seeding growth, plants were thinned at 10 cm intra spacing. The plants were routinely irrigated by drip irrigation at one week interval for the first month then the field was irrigated as needed. Irrigation was stopped one month before harvesting which started after 135 days from seeding at two times. Data were subjected to statistical analysis according [5].

RESULTS AND DISCUSSION

The results presented in (Table 5) indicate clearly that the European sort out-yielded those from Peru and according to yielding the varieties and strains tested can be categorized to three categories:

First Category (700-800 Kg)		Second Category (600-700 Kg)		Third Category (500-600 Kg)	
Danish Varieties	Yield (kg/fed)	Peruvian Strains	Yield (kg/fed)	Peruvian Varieties	Yield (kg/fed)
KVL 5204	800	P1	610	Utusay	520
		P2	620		
KVL 3704a	750	P3	615	Toledo	600
		P45	660		
KVL 3704b	710	P7	640	DM	550
		P8	670	P6	500

However, these results are in agreement with those obtained by [16,17].

Effect of Time of Planting and Plant Spacing on Yield of Quinoa Plants

Methodology: Two field trials were conducted at the experimental farm in Nuwaiba to study the effect of four dates of sowing quinoa seeds; 15th of November, 15th of December, 1st of February and 15th of February and two inter spacing, i.e. 15 and 20 cm apart in rows 40 cm apart.

Table 5: Effect of method of land preparation and different varieties and strain of quinoa on yield under Egyptian environment

Variety	Land preparation method: Till (ploughed)	No till	Average yield (kg fed^{-1})
KVL 3704 A	737.0	763	750
KVL 3704 B	707.0	713	710
KVL 5204	852.0	748	800
Toledo	580.0	620	600
Utusay	470.0	530	500
QP1	597.0	623	610
QP2	607.0	633	620
QP3	607.0	623	615
QP4	520.0	580	550
QP5	630.0	690	660
QP6	483.0	517	500
QP7	667.0	613	640
QP8	667.0	713	670
Averages	624.92	640.46	632.69

L.S.D. for interaction 60.77

The eight treatments were assigned in complete randomized block system and replicated for three times. Plot area was 42 m^2. Seeds of quinoa KVL 3704 B were sown at different rates according to treatment imposed. The seedlings, were irrigated routinely during the first month at five days interval, thereafter irrigation was applied as needed and stopped one month before harvesting which was according to weather conditions throughout the season for each date of planting after 140, 150, 132 and 130 days respectively. Harvesting was conducted twice by picking manually two times. The treatment were fertilized with urea at rate of 200kg N/fed (in the form of urea), phosphorus fertilizer at a rate of 31kg P_2O_5 (in the form of Calcium super phosphate) and potassium fertilizer at a rate of 72 K_2O (in the form of potassium salphate).

RESULTS AND DISCUSSION

Data presented in (Table 6) indicate that the yield of quinoa significantly increased with diminishing plant spacing from 20 cm to 15 cm. The data also indicate that there were gradual reduction in seed yield/fed with delaying time of seeding till mid of February. Reduction between the first and latter date was estimated to 60%.

Effect of Land Preparation System and Supplementary Irrigation on Growth and Yield of Quinoa under Rainfed Condition

Methodology: Field experiment was conducted at Matrooh experiment station for research to study the effect of supplementary irrigation under rain fed condition in north coastal region on growth and yield of quinoa.

The six treatments were the combination of two main variables: (1) Method of irrigation (rainfall only, rainfall + one supplementary irrigation and rainfall + two supplementary irrigation) and method of land preparation (seeding on flat and seeding on ridges).

The treatments were assigned in split plot design. Sub-plot area was 168m^2 and treatments were replicated three times. The average rainfall was 125mm during November and December. Supplementary irrigation was done by sprinkler irrigation system. The analysis of variance using least significant difference (LSD) was performed to estimate significance among the treatment imposed [5].

RESULTS AND DISCUSSION

The trends of plant height and the grain yield of quinoa per fed as influenced by method of land preparation and method of irrigation was similar. Values increased with increasing supplementary irrigation to the double (Table 7). On the other hand, seeding quinoa on flat land was ever superior to seeding on ridges. Thence, highest grain yield was obtained when seeding quinoa on flat and with two supplementary irrigations, in addition to the rainfall. The excess in grain yield over plants grown on ridges left to rainfall only was estimated to 111%. It could be concluded that to maximize yield of quinoa crop, there should be supplementary irrigations, which depends mainly on the average of rainfall in this region.

Table 6: Quinoa seed yield as affected by date of sowing and plant spacing

	Date of sowing				
Plant spacing	15th of November	15th of December	1st of February	15th of February	Mean
15 cm	767	741	462	280	526
20 cm	627	507	440	267	460
Mean	697	624	451	274	511

L.S.D. at 5% 122.11

Table 6: Effect of land preparation system and supplemental irrigation on growth and yield of quinoa under rainfed condition

Treatment	Trait	Plant height (cm)	Grain yield (Kg/fed)
Irrigation	Land preparation		
Rainfall only	Flat	35	222
	Ridge	28	205
Rainfall + one supplementary irrigation	Flat	40	365
	Ridge	35	315
Rainfall + two supplementary irrigations	Flat	47	433
	Ridge	37	403
LSD at 0.05%		4.21	38.76

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