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EVALUATING EGYPTIAN PEANUT CULTIVARS FOR USE IN THE SPACE PROGRAM

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ABSTRACT: As part of the National Aeronautics and Space Administration's Advanced Life Support program, several crops are being studied for possible use in bioregenerative life support to provide a source of nutritious food for planetary human space exploration. Peanut (*Arachis hypogea L.*) is among the list of crops selected for space missions and is an excellent source of oil and protein. Tuskegee University is currently studying peanut growth, nutrition and physiology in controlled environments. For this research, plants were grown hydroponically using nutrient film technique (NFT). Peanuts are grown in a soil-less culture in narrow troughs, and there is an ongoing search for new and improved, high yielding cultivars that are adaptable to growing in NFT. The ideal cultivar would be one with an erect growth habit, concentrating its gynophore and ultimately, pod production around the roots. The objective of this study was to evaluate Egyptian peanut cultivars to ascertain their possible use in future space missions. Two Egyptian cultivars, 'Giza 5' and 'Hybrid 8' were compared to the control 'Georgia Red'. Hybrid 8 produced the highest foliage dry weight when compared to Giza 5 and Georgia Red (224.9 vs. 163.1 and 92.9 g/plant, respectively). The same trend followed root dry weights for the three cultivars (16.1, 12.7 and 4.1 g/plant). Pod count, pod weight and mature seed weights were highest for Giza 5 and lowest for Hybrid 8. However, there were no significant difference between the harvest index for Georgia Red and Giza 5 but both were significantly higher than Hybrid 8 (0.16 and 0.18 vs. 0.05). Based on this study, it is recommended not to use Hybrid 8 in further hydroponics studies but Giza 5 appears to be a suitable cultivar for the NFT system.

INTRODUCTION

The National Aeronautics and Space Administration's (NASA) Advanced Life Support (ALS) program is evaluating several crops for possible use in the bioregenerative life support (BLS). This will give interplanetary explorers a source of nutritious food. Bioregenerative Life Support is based on the concept of using photosynthesis and transpiration to produce oxygen, food, and potable water, while removing carbon dioxide (Tibbitts and Alford, 1982). Potential candidate crop species must meet a list of criteria including high energy concentration, high nutritional composition, palatability, relative ease of processing, acceptable serving size and frequency, and storage stability (Tibbitts and Alford, 1982).

Peanut (*Arachis hypogea L.*) is among the list of crops selected for space missions, and, in addition to meeting the above listed criteria, is a potential source of oil and protein. Peanut is the 4th most important source of edible oil depending on cultivar, maturity and environmental conditions under which the crop is grown (Sanders et al., 1995). Runner, Virginia, Valencia, and Spanish are the four major market-types of peanuts grown in the United States. The total oil content varies from 44-56% (Ahmed and Young, 1982). Peanut is also high in protein with an average of 25% and ranges between 22-33% (Ahmed and Young, 1982).

There are approximately 180,000 faddans (acres) of surface irrigated lands in the Ismailia Governorate of Egypt. These lands are mostly flood irrigated and the peanut cultivars that are grown in this region appear to be a good candidate for inclusion in Controlled Environment Life Support System (CELSS) project. As with most arid regions, lands are only productive when adequate amounts of irrigation water is supplied. This condition mimics some of the features that are found in Nutrient Film Techniques (NFT). The Egyptian Government with the understanding that irrigation methods to conserve moisture be implemented distributed some of the recently reclaimed lands. Suez Canal University and Egypt's Ministry of Agriculture place a high priority on water use efficiency (WUE). Suez Canal University in collaboration with Tuskegee University is testing various approaches and cultivars to prevent and/or reduce excessive moisture losses. Using new irrigation techniques such as drip and sprinkler irrigation systems are given priority, especially, on newly reclaimed lands. Adamson (1989) studied irrigation methods and water quality on the grade and yield of peanuts and found that irrigation methods did not impact the oil quality.

Tuskegee University is evaluating peanut growth, nutrition and physiology in controlled environments. For this program, plants are grown hydroponically using NFT. This technique allows plant roots to be exposed to a thin film of nutrient solution within a trough or channel (Cooper, 1975; Morris et al., 1989).

Because plants are grown in a soilless culture in narrow troughs, there is an ongoing search for new and improved, high yielding peanut cultivars that are adaptable to growing in NFT. The ideal cultivar would be one with an erect growth habit, concentrating its gynophore and ultimately, pod production around the taproot. The objectives of this study were to evaluate elite Egyptian cultivars as to their suitability using NFT and their possible inclusion in the space program.

MATERIALS AND METHODS

This study was conducted at the George Washington Carver Agricultural Experiment Station, Tuskegee University, Alabama. The CELSS Project (NASA) provided the facilities. The study utilized two walk-in growth chambers (Conviron Model PGW 36, Controlled Environments, Pembina, ND). The study (CMBALPN-1) was initiated on February 26, 1999 and terminated on July 6, 1999 (130 days) using two Egyptian cultivars ('Hybrid 8' and 'Giza 5') and 'Georgia Red' as a control.

Starting Transplants

Seeds of Hybrid 8, Giza 5 and Georgia Red were sown in a growth medium of moistened commercial Jiffy Mix (Batavia, IL) in TLC Pro-Trays transplant flats (TLC Polyform, Inc., Plymouth, MN). Seeds were covered with approximately 0.6 cm of the growth medium. Transplant flats were placed in a germination chamber with a 14/10 hours daily light period, a matching 28/22°C thermoperiod, and a constant 70% relative humidity. Seeds/seedlings were watered every three days with de-ionized water, and seedlings were grown for approximately three weeks.

Treatments and Planting

Four seedlings from each cultivar were transplanted into each of three NFT growth channels. Channels were 15-cm wide, 15-cm deep and 1.2 m long. Prior to transplanting into the NFT growth channels, seedlings were carefully removed from the cells in the transplant flats, and excess growth medium was removed by rinsing the roots in tap water. In this way, damage to the developing root system was minimized. Seedlings were placed 25 cm apart through openings made in a flexible perforated PVC-1 grid. The grid is 0.32 cm thick containing perforations with a diameter of 0.32 cm on 0.56-cm centers. With such dimensions, entry of the developing gynophores is facilitated in the pod production zone.

Nutrient Solution

A modified half-strength Hoagland nutrient solution (Hoagland and Arnon, 1950) with an additional 2 mM of Ca and N were used. The solution was supplied to the plants in each channel from 30.4-liter reservoirs with in-line pumps (Little Giant Pump Co., Oklahoma City, OK). Growth channels were on a 1% slope to facilitate return of the nutrient solution to the reservoir by gravity flow. The nutrient solution was replenished once per week with a weak solution (one-third strength Hoagland) and pH adjusted to 6.5. Electrical conductivity ranged between 1000 to 1300 $\mu S\ cm^{-1}$. Solution temperature was similar to that of the air within each growth chamber.

Growth Chamber Conditions

Growth chamber conditions included a constant relative humidity of 70 $\pm$ 5%. The photosynthetic photon flux (PPF) at the top of the plant canopy (approximately 20 cm above the plants) averaged 500μmol m^{-2} s^{-1} and was provided by a mixture of cool-white fluorescent and incandescent lamps. The photoperiod was 14/10 h with a matching thermoperiod of 28/24C.

Harvest

The three peanut cultivars were harvested 130 days after transplanting. At harvest, plants were separated into foliage, roots and pods. Fresh weights of component plant parts were determined and pods removed from each plant. Pods were counted, weighed, and dried at 35°C for 72 h before separation into 'mature' or 'immature' and weighed. Pods were then shelled and seeds classified as ‘mature’ and ‘immature’, according to the technique of Rucker et al. (1994). Foliage and roots were dried at 70°C for 72 hours. Harvest index (HI) was calculated as a factor of the total weight of mature seeds over the total biological yield of the plant.

$$HI = \frac{\text{Total weight of mature seeds}}{\text{Weights of Foliage + root + mature seeds + immature seeds + pod shell}}$$

RESULTS AND DISCUSSION

To evaluate cultivars for use in the peanut CELSS program it must be realized that it is expensive and screening methods are very critical. Georgia Red is the standard cultivar used in the evaluation process because it has consistently done well over the years in NFT system. These results represent one of several runs used to evaluate Egyptian cultivars. Two weeks after transplanting the cultivars, Georgia Red started to flower and the Egyptian Cultivars (Hybrid 8 and Giza 5) flowered two weeks later.

One of the criteria that is used to indicate that a peanut cultivar is suitable for inclusion in NFT is its compact growth habit. Of the three cultivars evaluated in this study, Hybrid 8 had the greatest amount of foliage fresh weight (Table 1). Fresh weight of Hybrid 8 was 3.5 times that of Georgia Red and 1.7 times that of Giza 5. All three cultivars were significantly different from each other in both foliage and root dry weights (Table 1). Georgia Red had the lowest root and foliage weights and Hybrid 8 the most. The foliage to root (dry weight basis) ratio was 23:1 for Georgia Red; 14:1 for Hybrid 8 and; 13.1 for Giza 5. This shows that Georgia Red was the most compact of the three cultivars an indication of why it does so well in NFT trials. The foliage to root ratio also indicate the ability of Georgia Red to maximize its photosynthetic ability while reducing the overall rates of root respiration. This could possibly translate into higher pod yields.

There was no significant difference between Giza 5 and Georgia Red in the total number of pods per plant (Table 2). However, Giza 5 significantly out-yielded Georgia Red in the number of mature pods per plant (114.9 vs. 68.0) and fresh pod weight (50.3 vs. 38.3 g/plant). Hybrid 8 was significantly inferior to Georgia Red. In evaluating Giza 5 as a potential for inclusion in the CELSS program, it should be noted that it had greater than 2 times the number of mature pods as Georgia Red and four times that of Hybrid 8 (Table 2).

Table 1. Foliage and root weights of hydroponically grown peanuts.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Foliage fresh wt. (g)	370.2[c*]	1265.9[a]	770.4[b]
Foliage dry wt. (g)	92.9[c]	224.9[a]	163.1[b]
Root fresh wt. (g)	15.8[c]	179.8[a]	131.6[b]
Root dry wt. (g)	4.1[c]	16.1[a]	12.7[b]

*Any two means within a row with the same superscript are not significantly different

The data further show that the percent mature pods of total pods harvested for Giza 5 was 93.5%; Georgia Red had 64.4%; and Hybrid 8 82.1%. The average weight per pod was also greatest for Giza 5 (Table 2). Average pod weight was 2.14 g for Giza 5; 1.44 g for Hybrid 8; and 1.14 g for Georgia Red.

Table 2. Pod number and weight of peanuts grown using Nutrient Film Technique.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Pod #	59.5[a*]	28.0[b]	53.8[a]
Pod fresh wt. (g)	68.0[b]	40.3[c]	114.9[a]
Mature pods (#)	38.3[b]	23.0[c]	50.3[a]
Mature pod wt. (g)	31.0[b]	17.4[c]	63.9[a]

*Any two means within a row with the same superscript are not significantly different

Immature seeds often result in a reduction of the harvest index. Table 3 shows that Georgia Red had the greatest number of immature seeds (27.3) while Hybrid 8 and Giza 5 were not significantly different (8.3 and 9.3, respectively). Although there were higher amounts of immature seeds for Georgia Red plants, these weighed less than either Giza 5 or Hybrid 8.

While the highest shell weights were recorded for Giza 5 and the lowest for Hybrid 8 (Table 3), it must be remembered that Hybrid 8 had the lowest pod number and weight (Table 2).

Table 3. Immature seeds and shell weight of peanuts grown hydroponically.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Immature seed (#)	27.3[a*]	8.3[b]	9.3[b]
Immature seed wt. (g)	0.5[a]	0.8[a]	0.8[a]
Shell wt. (g)	6.7[b]	4.9[c]	10.1[a]

*Any two means within a row with the same superscript are not significantly different

Table 4 shows that Giza 5 had the highest mature pods for the total number of pods produced. For every pod of Giza 5 harvested there was 1.57 seeds/pod. On the other hand, there were 1.04 and 1.10 seeds for each pod of Georgia Red and Hybrid 8 harvested, respectively. Data from Table 4 also show that Giza 5 had the greatest number of mature seeds per plant while Hybrid 8 had the lowest.

Additionally, seeds from mature pods of Giza 5 plants weighed 0.63 g compared to 0.44 and 0.40 g per seed for Hybrid 8 and Georgia Red, respectively. There was no significant difference between the harvest index of Georgia Red and Giza 5 (0.16 vs. 0.18). However, both were significantly greater than Hybrid 8.

Table 4. Harvest Index and mature seed weight of hydroponically grown peanuts.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Mature seed (#)	62.0[b*]	30.8[c]	84.5[a]
Mature seed wt. (g)	25.0[b]	13.7[c]	53.2[a]
Harvest Index	0.16[a]	0.05[b]	0.18[a]

*Any two means within a row with the same superscript are not significantly different

CONCLUSION

The edible portions of plants are very important in long-term space travel. In order for the bioregenerative life support process to be efficient, there must be a measure of the crop's productivity that we take along in space. The compact nature of the crop and its ability to produce in limited space is evident in the harvest index and other yield components. To that end, Giza 5 is well suited for further evaluation in the CELSS program at Tuskegee University and further studies have been conducted using this cultivar. While Hybrid 8 is an excellent cultivar in the flood, drip and overhead irrigation systems in Egypt, it does not appear to be a suitable candidate for the CELSS project and was removed from further evaluations.

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REFERENCES

Adamson, F. J. 1989. Irrigation method and water quality effects on plant yield and grade. Agron. J. 75:1005-1009.

Ahmed, E. M. and C. T. Young. 1982. Composition, quality, and flavor of peanuts. Pp. 655-688. In: H. E. Pattee and C. T. Young (eds.) Peanut Science and Technology. Amer. Peanut Res. Educ. Soc. Yoakum, TX.

Cooper, A. J. Crop production in recirculating nutrient solution. 1975. Sci. Hortic. (Amsterdam) 3:251-258.

Hoagland, D. R., and D. J. Arnon. 1950. The water-culture method for growing plants without soil. California Agric. Exp. Stn. Circ. 347, Univ. of California, Berkeley.

Morris, C. E., P. A. Loretan, C. K. Bonsi, and W. A. Hill.. 1989. Movable root contact pressure plate assembly for hydroponic system. U.S. Patent 4860480. Date issued. 29 August.

Rucker, K. S., C. K. Kvien, G. Vellidis, N. S. Hill, and J. K. Sharpe. 1994. A visual method of determining maturity of shelled peanuts. Peanut Sci. 21:141-146.

Sanders, T. H., J. A. Lansden, R. L. Greene, J. S. Drexler, and E. J. Williams. 1995. Oil characteristics of peanut fruit separated by nondestructive maturity classification method. Peanut Sci. 9:20-23.

Tibbitts, T. W. and D. K. Alford. 1982. Controlled ecological life support system: Use of higher plants. NASA Conf. Pub. 2231. Ames Research Center, Moffet Field, CA.