ICE - Quadratic Functions

The African nation of Tanzania (see Figure 1[1]) includes portions of some of the largest lakes in the world, as well as Mount Kilimanjaro (the highest peak on the African continent at 19,335 feet - see Figure 2[2]).

Figure 1: Map showing the east African nation of Tanzania.

During the twentieth century, Tanzania was the site of research efforts in anthropology, archaeology and primatology that laid much of the foundation for the modern views of who we are, where we came from, and what we are doing.

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[1] Source: CIA World Fact Book, 2000. Image source: http://www.odci.gov/cia/publications/factbook/geos/tz.html

[2] Image source: http://www.gorp.com/

Figure 2: Mount Kilimanjaro.

For example, in the northern part of the country lies Olduvai Gorge (see Figure 3[3]) where, in the 1960's, archaeologist Louis Leakey found the oldest remains of a hominid (specifically Homo habilis) - a creature thought to be an ancestor of modern humans. Subsequent excavations in the area have yielded a wealth of information about the possible origins of our species.

In the eastern part of Tanzania, noted primatologist and chimpanzee researcher Jane Goodall established a research station near the Gombe springs (see Figure 4[4]). The observations of chimpanzee behavior made by Dr. Goodall and her colleagues have drastically changed our views of apes as simple-minded brutes, and fundamentally reconceptualized ideas of what it means to be human.

Figure 3: A portion of Olduvai Gorge in the Serengeti National Park.

Figure 4a: Jane Goodall.

Figure 4b: Part of the Gombe research area on the shores of Lake Tanganika.

Figure 4c: One of the residents of the Gombe research station.

[3] Image source: http://emuseum.mnsu.edu/archaeology/sites/africa/olduvai_gorge.html

[4] Image source: http://www.pbs.org/wnet/nature/goodall/relatives.html

Tanzania gained independence in 1985 and has faced severe economic hardships exacerbated by generally low levels of education[5], extreme poverty[6], political corruption[7] and upheaval[8], an unprecedented influx of refugees from the Rwandan genocide, and severe drought and famine[9].

The CIA World Fact Book states that 51.1% of Tanzanians live below the poverty line. According to UNICEF[10], about 33% of Tanzanians (mainly children) are chronically undernourished, with lack of animal protein in the diet being a major problem[11]. According to the Tanzanian government:

> "Agriculture is the foundation of the Tanzanian economy. It accounts for about half of the national income, three quarters or merchandise exports, is the source of food and provides employment opportunities to about 80% of Tanzanians ... It is rain-fed agriculture. Food crop production dominates the agricultural economy 5.1 million hectares are cultivated annually, of which 85% is under food crops ... The major constraint facing the agricultural sector is the falling labor and land productivity due to application of poor technology, dependence on unreliable and irregular weather conditions."

Figure 5: The leaf on the left is from a healthy potato plant. The leaf on the right is from an identical plant grown in nitrogen deficient soil.

Given the importance of agriculture to the Tanzanian economy, anything that can be done to improve the productivity of the land holds potential to have a substantial positive effect on the welfare of the Tanzanian people. In this activity, you will analyze the results of a scientific study to try to develop some information that may be of use for improving the quality and yield of Tanzanian agriculture. The data given in this ICE are drawn from the published scientific work:

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[5] Source: Tanzanian Ministry of Education, http://www.tanzania.go.tz/

[6] Source: Tanzanian Ministry of Economics, http://www.tanzania.go.tz/

[7] Source: Corruption Perception Index Surveys 1995-2001. Transparency International, Inc.

[8] Source: US Department of State (2001) Consular Information Fact Sheet - Tanzania. (Available on-line at: http://travel.state.gov/tanzania.html)

[9] Source: Capdevevila, Gustavo. (1997) "Tanzania - Population: Millions of peasants facing drought, famine." Inter Press Service, September 16, 1997.

[10] Source: http://www.reliefweb.int/

[11] Source: UNICEF, "The State of the World's Children, 1998." Available on-line from: http://www.unicef..org

- Frederiksen, J.H. and Kategile, J.A. (1980) "The effects of nitrogen fertilization and time of cutting in first growth in *Brachiaria brizantha* on yield, crude protein content and in vitro digestibility." *Tropical Animal Production*, **5**(2): 136-143.

In Tanzania, the soils used for crop production are generally deficient in nitrogen. Nitrogen deficiency leads to stunted plants of poor quality. Frequently, plants grown in nitrogen deficient soils will exhibit a yellowing of the leaves (chlorosis) and poor nutritional quality[12]. An example of a healthy plant and a plant grown in nitrogen deficient soil may be see in Figure 5[13].

A further problem lies in the fact that crops can only be raised during periods of rain, as this is the only available form of agriculture. In their study, Frederiksen and Kategile investigated:

1. The effects of applying a nitrogen-rich fertilizer (ammonium sulfate) on the growth of *Brachiaria brizantha*, and,
2. The effects of the time of harvesting on the yield of a *Brachiaria brizantha* crop in Tanzania.

Brachiaria brizantha ***is a tropical grass (see Figure 6[14]) that grows rapidly and can provide a good source of hay for farm animals. This grass can also be planted on marginal land that is not easy to cultivate for other crops. When fed to animals such as cows, sheep and goats, the hay can be converted into valuable animal products such as milk and meat.***

Figure 6: A stand of *Brachiaria brizantha.*

Some of the data obtained in the study is shown in Table 1 below. The entries in Table 1 give the amount of dry matter (i.e. hay) harvested in units of tons per hectare. The units of nitrogen fertilizer are kg per hectare, and the units of growing time are weeks.

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[12] Source: Manske, L.L. (1999) "Annual nutritional quality curves for graminoids in the northern Great Plains." Dickinson Research Extension Center, North Dakota State Univerity.

[13] Image source: http://www,luminet.net/~wenonah/min-def/potato.htm

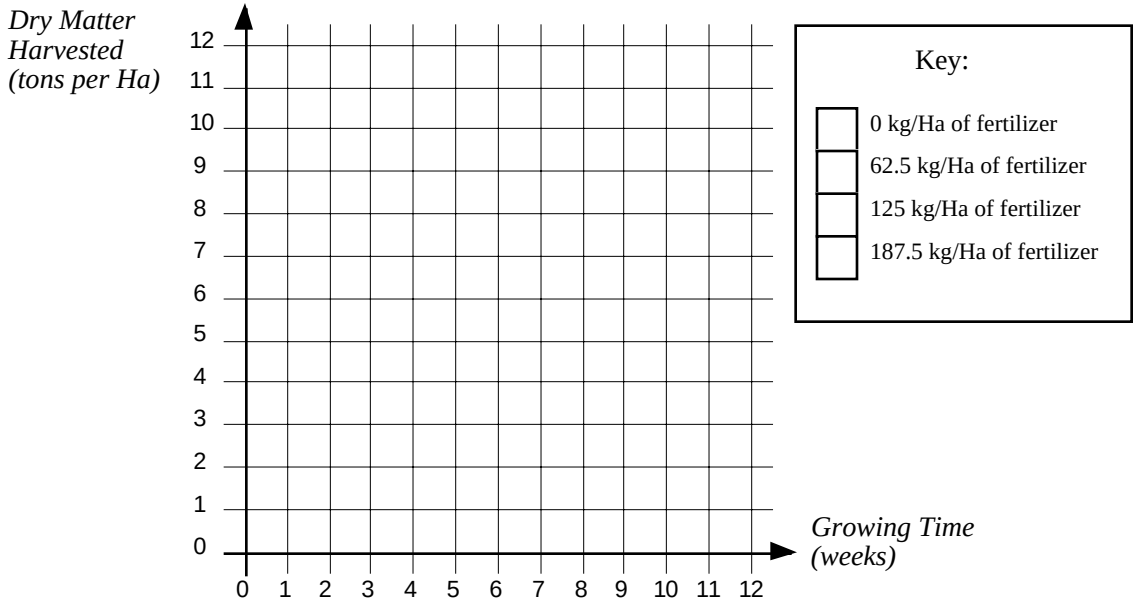
[14] Image source: http://www.stetnet.com.br/gasparim/brabri.htm

	Time=1	Time=2	Time=3	Time=4	Time=5	Time=6	Time=7	Time=8
Nitrogen =0	1.375	1.892	2.301	2.602	2.795	2.88	2.857	2.726
Nitrogen =62.5	2.142	3.178	4.078	4.842	5.470	5.962	6.318	6.538
Nitrogen =125.0	1.529	3.066	4.381	5.474	6.345	6.994	7.421	7.626
Nitrogen =187.5	1.172	3.128	4.768	6.092	7.100	7.792	8.168	8.228

Table 1: Data on growth of *Brachiaria brizantha.* (After Frederiksen and Kategile, 1980.)

- ***The first question that the researchers were interested in was the effect of applying nitrogen fertilizer on the growth of*** *Brachiaria brizantha****. Based on the data in the table, describe the effects in words. What practices would you recommend to Tanzanian farmers?***

- ***The second question that the researchers were interested in was the effect of the growing time on the harvest. Use the axes to plot graphs of amount of dry matter harvested versus growing time. Plot a separate graph for each different level of nitrogen fertilizer.***



- ***Select one of the curves that you have plotted. Find an equation that accurately describes the relationship between amount of dry matter and growing time.***

- ***According to your equation, when should the Tanzanian farmers harvest their hay?***

- ***Suppose that*** $H(t)$ ***gives the amount of dry matter harvested after*** t ***weeks when no fertilizer is applied. How would you modify this function so that it would describe the amount of dry matter harvested when 187.5 kg/Ha of fertilizer were applied?***