TABLE OF CONTENTS

VI. SUMMARY

Soil fertility management is just one aspect of farm management and has to be seen in the context of the farmers' struggle to adjust investments in crop and livestock production to the market, the needs, knowledge, interests, and health of all members of the household. Therefore this study of assessing soil fertility management of Kafr Fazara was done in the context of a farming system. A farming system which is a unit consisting of the household (household factors) that manages its resources such as crop, livestock, and off-farm resources in an environment that is dependent on environmental factors (*e.g.* climate, topography, and soil). The farming system is also a part of a larger society (external factors) that affects the farming system *e.g.* by policy, access to external information, market facilities, and off-farm opportunities. The soil nutrients management is a part of the resulting farming system, and can be quantitatively evaluated by means of nutrient budgets and balances. Decreasing soil fertility has raised concerns about the sustainability of agricultural production at current levels. Future strategies for increasing agricultural productivity will have to focus on using available nutrient resources more efficiently, effectively, and sustainably than in the past. Integrated management of the nutrients needed for proper plant growth together with effective crop, water, soil, and land management, will be critical for sustaining agriculture over the long term.

It is very important to see this research study in its context as a part of a comprehensive research project that employed a *holistic agro-ecosystem management approach* with the ultimate and general objective of helping Kafr Fazara farmers in El-Fayoum to manage their

agroecosystem to enhance community livelihood. This will be achieved through assessment of soil mineral fertility on a detailed farm scale. The current research findings in collaboration with the other project research studies will contribute to developing SSCM for Kafr Fazara in order to enhance agroecosystem productivity, hence; community livelihood.

To achieve such objectives, soil sampling strategy was designed using cadastral maps of Kafr Fazara (Scale 1:2,500). A grid scheme (150 m spacing) covering the whole Zemam of Kafr Fazara was designed where 300 soil locations were geo-referenced to cover the studied area. Surface and subsurface soil samples were obtained to cover the root zone from each geo-referenced location after eliminating the non agricultural locations to end up with 275 sample location. Main chemical properties and fertility analyses were measured according to standard methods.

Descriptive statistical analyses for non-spatial parameters were obtained using univariant statistical analyses and included: minimum, maximum, mean, median, standard deviation, coefficient of variance, skeweness, and kurtosis. These parameters were carried out for measured soil attributes at surface and subsurface locations.

On the other hand, soil spatial variability analyses of soil properties were determined. The semi-variogram was used to model soil properties. Actual variation for these properties was fitted to one of the known semi-variogram models (Linear, Gaussian, Exponential or Spherical). The semi-variogram's parameters were calculated using the GS^+ geostatistical analysis software for many lags. The selected best fitted-model was chosen based on the correlation values.

Punctual kriging technique was used to estimate the values according to the fitted semi-variogram model at un-sampled locations and kriged maps for soil characteristics were obtained.

Finally, the ALES-Arid program was used to estimate land capability and soil suitability to different crops as well as predicting soil productivity to wheat and corn.

The results reflect a high variability of soil salinity and available phosphorus where these attributes had the highest coefficient of variance among all soil properties (1.26 & 1.32). Cation exchange capacity (CEC) values ranged between 28.98 and 57.97 cmol (+)/kg and clay content varies between 20 to 38%. SOM percent ranged between 0.45 and 4.48, available phosphorus varies between 0.23 to 45.0 mg/kg soil, and available nitrogen varies between 43.75 to 298.95 mg/kg soil. Available potassium and nitrogen in the surface and nitrogen in the sub-surface layers had the highest nugget variance (7800, 840 and 740) which indicate their strong spatial dependence and inherited variability. The maximum interpolation distance was 8.11 Km for exchangeable K in surface and O.M of subsurface layers, while it was 7.11 Km for EC of the two layers and Available P and K in subsurface layers. These distances are the optimum ones for designing any future sampling strategy for monitoring these soil properties. The nugget-sill ratio of pH, K, Cu, and Mn in the surface layer were (24.68,10.41, 0.24, & 0.03) which indicate strong spatial dependence, while moderate spatial dependence was found for available nitrogen and phosphorous in surface layer (41.75, 43.28). The other parameters had weak spatial dependency.

In general, the indigenous soil nutrients in the studied area were sufficient for plant growth except for phosphorus (lower than 3 mg/kg) represented 66.42% and 87.54% for surface and subsurface samples, respectively. High values of N and K in some sites may be due to fertilizations around the sampling time. General land use capability for the study area was classified as C2 (good), soil indices ranged between 60.12 to 79.28 which indicate good capability with the soil is the limiting factor. Other part of the study area was classified C3 (Fair), soil indices ranged between 41.47 to 59.44 and C4 (poor), soil indices ranged between 34.98 to 38.17. Data indicated that most of the studied area are highly suitable (S1) to moderately suitable (S2) for wheat, cotton, date palm, sorghum, tomato, potato, berseem, and sunflower. Regarding maize, fababean, and citrus, they are moderately suitable (S2) to marginally suitable (S3).

The model predicted an average yield for wheat and corn to be 14.65 and 12.63 ardab/fed, respectively. These values are less than the local and national average for wheat and far away for corn. This may be due to the low soil suitability in the study area resulted from high soil salinity and poor management practices in the study area.

In general, indigenous soil fertility may be adequate in most investigated sites, however general low land productivity observed could be attributed to poor soil management.

Soil fertility classes for the studied soils were estimated using the ALES-Arid program and based on the minimum data set required to estimate the overall soil fertility. Soil fertility indices were calculated based on SOM, available N P, and K. The data indicated that more than 98 % of the area is located in class C3 and C4 indicating low soil fertility (Fig. 43). Underlying soil fertility problems such as high soil salinity, phosphorous deficiency, and micronutrient imbalances can limit plant response to nitrogen, phosphorus, and potassium fertilizers.

The results obtained from this study could be used to help make crucial management decision related to this village in order to enhance soil productivity. In general, indigenous soil fertility may be adequate in some of the investigated sites, however general low land productivity observed could be attributed to poor soil management. To formulate an integrated site-specific soil fertility management (SSFM) we should consider both soil mineral and bio- fertility components. In this context, a complementary Ph.D. thesis on site-specific Soil Quality/Health assessment is being conducted in parallel. A good record of site-specific crop yields is also required to make possible an integrated SSFM and the project is now conducting such survey. Putting all these pieces of the bezel together and connecting them such objective of formulating SSCM for Kafr Fazara will be achievable.

A nutrient budget is a procedure that accounts for inputs and outputs of nutrients in a defined system, and the nutrient balance refers to the difference between the sum of inputs and outputs flows. The kind of nutrient balance to be established is determined by the purpose of the study, the type of data available, and the boundary of the system. Nutrient budgets and balances at farm level can be used as tools to analyze the whole system, to identify unutilized nutrient sources or nutrient accumulations, and to assess the level of integration between farm units. Field balances, on the other hand, can be used to identify whether nutrients are accumulated or depleted from the soil, and to assess the risk for nutrient losses to the wider environment. A field balance can be established for a single crop, or for a whole crop rotation and thereby serve as an evaluation of the cropping system. Nutrient budgets can be seen as a point of departure for further analyses of the system. Nutrient budgets may be used to calculate nutrient use efficiency, which is the efficiency with which a nutrient is transferred from one pool to another. It may, for example, be used to calculate the percentage of applied fertilizer that is taken up by the crop or exported from the farm in crop products. Similarly, it may be used to calculate the efficiency with which nutrients in animal feeds are converted to animal products. Nutrient use efficiencies (NUE) may differ greatly between crops and farming systems and there are as yet no standard values for these efficiencies. Comparison of the NUE for the same crop but between farming systems, or for different crops on the same soil type provides a basis for further studies to reveal the causes of the observed differences. A common way of expressing NUE is as the ratio between nutrient output and input (nutrient output/nutrient input x 100). For the crop system this way of calculating NUE does not take into accounts the availability of the nutrients to the crop. Thus the NUE calculated may need to be evaluated in relation to the retention capacity and availability of nutrients in the soil. High nutrient retention and/or low reserves of available nutrients would require higher nutrient additions in order to meet the crop need , which would result in a low NUE.

The soil's ability to deliver or retain nutrients depends on soil type, nutrient management history and the prevailing soil processes.

Nitrogen and P may also be accumulated in the soil by incorporation in organic matter. Conversely, NO3-N may be lost from the system by leaching below the rooting depth or by denitrification.

Nutrient management is affected by the farmer's decisions, which in turn depend on several socio-economic factors including income, knowledge, perceptions about soil fertility and fertilizers and access to external information on crop nutrient need. Participatory methods enable people to share, enhance, and analyze their knowledge, which also makes them useful for gathering information about farmers' rationales for their decisions. The common feature of participatory methods is that the active participation of the farmers or the rural communities is required. In the other part of the project (e.g., the socioeconomic studies) we have applied the participatory methods referred to as participatory rural appraisal (PRA), and have been developed from the areas of agroecosystem analysis, to get the views and perceptions of the farmers in their agroecosystem problems. It is believed that all these directions of the research project would allow us at the end to formulate a SSCM for Kafr Fazara.

It is important to understand that SSCM provides a powerful tool for the sustainable management of soil resources. This help making informed decisions on the following aspects of the farming system:

- Deciding the suitable crop type and genotype.
- Organic and inorganic inputs on real time spatial and temporal basis.
- Formulate site-specific irrigation management
- Site-specific soil reclamation and restoration of problem areas.

Finally, SSCM provides a good basis for economic viability of management soil decisions. The findings of this research thesis – in combination with the site-specific soil quality/health assessment and the survey of soil crop yields – will contribute to the formulation a comprehensive SSCM for Kafr fazara. Such informed-management decisions will help farming community restore the function and integrity of their agroecosystem and thus enhance community livelihood.