# U.S. CIVILIAN RESEARCH & DEVELOPMENT FOUNDATION (CRDF)
## COOPERATIVE GRANTS PROGRAM

### FINAL PROJECT REPORT

### SECTION I: Public Summary

### Award Number: ZB1-2050


**Public Summary (English)**

Uzbekistan is an agrarian country. Cotton and wheat are major crops in the country. Other important crops include corn, alfalfa, sugar beet, vegetables and fruits. The country geographical location is deep continental; and consequently, precipitation is low and erratic. As a result, agricultural production in the country, as well as in the whole of Central Asia, is largely based on irrigation. Therefore, irrigation water supply is the first factor of limitation of crop yield in the region. Rainfed agriculture in the country is characterized by scanty productivity.

Uzbekistan gained its independence in 1991. Since then, the country has begun reforming the agriculture sphere with the foremost aim to be self-sustaining in grain production. Thus, areas under cotton have been diminished and areas have been increased for irrigated winter wheat, sugar beet, etc.

It should be noted that wheat and sugar beet are comparatively new crops for the irrigated zone of Uzbekistan and, therefore, research with the crops has only begun. Further investigations must be performed on irrigation, fertilization, soil tillage and other relevant issues, which are the keystones of the crops' production technology.

We began investigations on elaboration of optimal water use and irrigation scheduling of winter wheat and sugar beet in four soil types of Uzbekistan, using modern methods and equipment. Field and lysimeter experiments were carried out at the Central Experiment Station (Tashkent) and three Provincial Branch Stations (Syrdarya, Kashkadarya and Khorezm) of the National Cotton Growing Research Institute of the Republic of Uzbekistan. Volumetric water contents of the soil profiles were measured by soil moisture neutron probes (SMNP), which were calibrated for each soil type. We explored advantages of the use of the SMNP (Campbell Pacific Nuclear model Hydroprobe-503 DR 1.5) in comparison with the traditional gravimetric method. These include:

- Fast measurement of soil water content (savings of time and labor)
- Availability of measurement of soil water content during whole year (even in winter)
- Possibility of data loading from SMNP to PC directly

On the basis of the first year of research (the investigations are continuing), we found optimal parameters of water use and irrigation scheduling for winter wheat and sugar beet, which save irrigation water up to 25.4% and increase the crop yields for winter wheat on the order of 18.3 to 50.5%, and for sugar beet on the order of 7.7 to 8.3%.

## Public Summary (Russian)

Узбекистан – аграрная страна и ее основными культурами являются хлопчатник и пшеница. В стране также широко возделываются кукуруза, люцерна, рис, сахарная свекла, овощи, фрукты и другие культуры. Глубокая континентальность географического положения, засушливость, обилие света и тепла, ничтожное количество атмосферных осадков в регионе позволяет возделывать сельскохозяйственные культуры исключительно при искусственном орошении, что является главным лимитирующим фактором урожайности. Богарное земледелие в стране характеризуется небольшой продуктивностью. Следует отметить, что после приобретения статуса независимого государства в 1991 г, Правительство Узбекистана наметило курс на самообеспечение народа продуктами сельскохозяйственного производства, и в первую очередь, зерном. Были сокращены площади под хлопчатник при одновременном увеличении их под озимую пшеницу, сахарную свеклу и другие культуры на орошаемых почвах.

Необходимо учесть, что пшеница и сахарная свекла в условиях орошаемого земледелия Узбекистана являются новыми культурами и научно-исследовательские работы с ними находятся в начальной стадии. Недостаточно исследований с этими культурами по вопросам орошения, применения удобрений, обработки почвы и другим важным аспектам.

Исходя из вышеизложенного, нами, в условиях наиболее распространенных четырех почвенных типов Узбекистана, с использованием современных методов и приборов, начаты эксперименты по разработке оптимальных режимов орошения озимой пшеницы и сахарной свеклы. Были проведены полевые и лизиметрические опыты в сети провинциальных филиалов Узбекского научно исследовательского института хлопководства. Влажность различных слоев почвы в исследованиях определялась с помощью нейтронных влагомеров, которые были предварительно откалиброваны в полевых условиях для соответствующих почв. Выявлены преимущества использования нейтронного влагомера марки «Hydroprobe-503DR 1.5’’» в экспериментах по сравнению с традиционным гравиметрическим (термостатно-весовым) методом. Ниже приводим некоторые из них:

- Оперативность определения влажности почвы до глубины 3 м и более (значительная экономия времени и труда)
- Доступность проведения измерений круглый год независимо от погодных условий
- Возможность загрузки данных из влагомера прямо в компьютер для проведения дальнейших расчетов

На основании одногодичных предварительных результатов (исследования продолжаются) определены наиболее оптимальные параметры водопотребления и режимы орошения озимой пшеницы и сахарной свеклы, позволяющие экономить ценную оросительную воду на единицу урожая (до 25,4 %) при одновременном повышении урожайности : пшеницы от 18,3 до 50,5 % , сахарной свеклы от 7,7 до 8,3 %.

## CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

### SECTION II: Technical Report

### Award Number: ZB1-2050

### Technical Report

The Republic of Uzbekistan, formerly part of the Soviet Union, comprises twelve provinces and the Republic of Karakalpakstan. About 27 million people live on a total surface of 447,000 square kilometers. Its geopolitical location between Russia, China and the Islamic world makes it a valuable interlocutor. About 60% of the country is desert or semi-desert with only four million hectares of the area cropped. With annual rainfall of 110 to 220 mm, Uzbekistan's climate is that of the dry mid-latitude desert, which is characterized by hot summers and cold winters.

Agriculture in Uzbekistan, which was and still is the largest sector in Uzbekistan's economy, accounting for about 30% of GNP and 45% of total employment, depends almost completely on irrigation. Water, used for hydro-electricity generation and irrigation, is supplied by two major river systems: the Amu-Darya and Syr-Darya, which also supply neighboring countries Kyrgyzstan, Tajikistan, Afghanistan (Amu-Darya only), Turkmenistan and parts of Kazakhstan.

Agricultural enterprises involve 32 million hectares (ha), but only 28.1 million ha are used. Arable land totals 4.5 million ha, of which 4.2 million ha is irrigated. Irrigated land comprises about 10% of the territory and produces more than 95% of total agricultural output. After 1991, areas under cotton were diminished and areas were increased for irrigated winter wheat. Cotton and cereals occupy 1.4 million ha and 1.0 million ha, respectively. The country produces about 4.0 million metric tons of seed cotton and 3.5 million metric tons of wheat yearly.

Water is vital for the Republic. About 85% of available water resources are used for agriculture. Between 1960 and the early 1980s, the irrigated area rose from about 2.3 million ha to 4.2 million ha, becoming more than 50% of the total for Central Asia. However, by the mid-1980s it had became clear that water resources were being over exploited.

Since 1991, the Central Asian countries have continued their dispute on meeting increasing water demands. Since water needs could not be met, the lack of water has gradually devastated the irrigation dependent cotton, winter wheat and other major crop production. In addition, it has imposed the ecological catastrophe within the Aral Sea Basin, at the tail end of the river systems of Uzbekistan. The Aral Sea, which is a large inland body of water with socio-economic and ecological importance for the region, has lost nearly two thirds of its volume and half of its surface area due to excessive diversion of water for irrigation from the rivers draining into it.

Since 1999, the situation has grown worse. In addition to the river water deficits in Uzbekistan, the northwestern region of the country has had to cope with the worst drought and water shortage in living memory.

Furrow irrigation (flood irrigation in paddy field) dominates the current farm practice of Uzbekistan. More efficient water use could be implemented through introduction of new methods.

These pressures led to the need for special research, where the influence of water and other agro-physical parameters of four major soils of Uzbekistan on growth, development and productivity of winter wheat and sugar beat were investigated. The main goal of the research was development of optimal parameters for water use (ET) and irrigation scheduling of these cultivars with the use of advanced methods and devices.

Field experiments were conducted in different soil and climatic regions of Uzbekistan that comprise a major part of the irrigated zone, stretching from piedmont to semi-deserts, including the:

- Central Experiment Station of UNCGRI in Tashkent: old irrigated typical gray soil, medium loam, water table is more than 15 m deep (automorphic type of soil formation).
- Syrdarya Branch Station: meadow-gray soil, light loam, moderate saline; underground water level is 2.0 to 2.5-m deep (semi-hydromorphic type of soil formation)
- Khorezm Branch Station: old irrigated meadow alluvial soil, clay loam, light saline; underground water level is 1.5 to 2.0-m deep (hydromorphic type of soil formation)
- Kashkadarya Branch Station: newly irrigated "takyr" soil, clay loam, light saline; water table is more than 3.0-m deep (transitional soils from the automorphic to hydromorphic)

An important key thrust of the investigations was measurement of soil profile water content. For this purpose we used the soil moisture neutron probe (SMNP) (Campbell Pacific Nuclear International, model Hydroprobe-503DR1.5), which was calibrated for each soil condition under guidance of the USA Co-PI during his expert and back-stopping missions to Uzbekistan. In addition, researchers from headquarters in Tashkent and Provincial Branch Stations had a one-week training in Tashkent on calibration and use of SMNP under the US Co-PI's guidance. Also, the project group was sent to Turkey (Prof, Dr.C.Kirda, Cukurova University, Adana) for training of one month duration on calibration and use of neutron probe and tensiometers.

Calibration of the SMNP was performed using methods describe in Evett and Steiner[1] (1995) The PVC access tubes were installed in the field to 2.0-m depth, in two replicates in each of two key plots of 10 square meters each. A wet site plot was irrigated to field capacity using approx. 4,500 $m^3$ of irrigation water. Preparation of a non-irrigated plot as the dry site was done by crop and field management over the preceding year. Volumetric water content of soil profiles were measured by both SMNP and volumetric/gravimetric methods for comparison. Calibration equations were calculated for the soils and important soil layers (Table 1). These were used for determination of irrigation rates and times for winter wheat and sugar beet during the growing season.

Measurements of volumetric water content of soil profile were conducted twice a week and in two replicates during the experiments by SMNP to 2-m depth and for each 20-cm soil layer separately. Before each measurement, a standard count ($C_S$) of the SMNP was determined in five replicates. As a start point for investigations on soil moisture, we adopted the field capacity ($F_C$) index, which was for: Tashkent, 0.298 $m^3$ $m^{-3}$; Syrdarya, 0.348 $m^3$ $m^{-3}$; Kashkadarya, 0.340 $m^3$ $m^{-3}$; Khorezm 0.348 $m^3$ $m^{-3}$; and Fergana, 0.336 $m^3$ $m^{-3}$. Irrigations were scheduled when soil moisture in the root zone was depleted by the crop to specific fractions of $F_C$ (for instance, irrigation at 70% of $F_C$).

The experiments with winter wheat were carried out in three replicates and comprised four treatments. Each treatment consisted of scheduling irrigations at specific percentages of $F_C$ during each of three plant growth periods as follows. (In Kashkadarya the scheme was slightly corrected because of specific climate and soil conditions.):

1. 65-65-60% of $F_C$
2. 70-70-60% of $F_C$
3. 75-75-60% of $F_C$
4. 80-80-70% of $F_C$

[1] Evett, S.R., and J.L. Steiner. 1995. Precision of neutron scattering and capacitance type moisture gages based on field calibration. Soil Sci. Soc. Amer. J. 59:961-968.

where the first of the three levels of $F_C$ (e.g. **65**-65-60%) was used from germination to shooting stage of the crop; the second level (e.g. 65-**65**-60%) was used from shooting to the milk-wax stage of grain ripeness; and the third level (e.g. 65-65-**60**%) was used from the milk-wax stage to full grain ripeness.

Plot area in the experiments was 240 $m^2$ (4.8 m by 50 m). In the experiments we also measured: seed germination, phenological observations, dry mass formation by crop, yield, and agro-physical and nutritional properties of soil. Irrigation water quantity used for each treatment was measured by special discharge (Weir of Chippoletty).

Table 1. Calibration equations for soil moisture neutron probes (SMNP) for different locations and soil layers in Uzbekistan. Equations are in terms of volumetric water content ($\theta$, $m^3\ m^{-3}$) and count ratio ($C_R$)

| Location | Soil layer (cm) | Equation | Soil layer (cm) | Equation |
|---|---|---|---|---|
| Tashkent | 10 | $\theta = -0.058 + 1.650C_R$ | 40, 60, 80 | $\theta = -0.157 + 0.357C_R$ |
| SMNP #H390104791 | 20 | $\theta = -0.279 + 0.4804C_R$ | 100 – 160 | $\theta = - 0.04 + 0.250C_R$ |
| Tashkent | | | | |
| SMNP #H301105941 | 10 | $\theta = -0.0219 + 2.1145C_R$ | 30 – 150 | $\theta = -0.0005 + 0.2276C_R$ |
| Syrdarya | | | | |
| SMNP #H300205497 | 30-50 | $\theta = 0.051 + 0.217C_R$ | 70 – 170 | $\theta = -0.01 + 0.268C_R$ |
| Kahkadarya | 10 | $\theta = 0.0098 + 0.401C_R$ | | |
| SMNP #H301105944 | 30-70 | $\theta = -0.0815 + 0.312C_R$ | 90 – 150 | $\theta = -0.0656 + 0.2942C_R$ |
| Khorezm | 10 | $\theta = 0.0208 + 0.262C_R$ | | |
| SMNP #H300205496 | 30-70 | $\theta = -0.1075 + 0.3424C_R$ | 110 - 170 | $\theta = -0.1481 + 0.3404C_R$ |
| Fergana | 10 | $\theta = 0.0559 + 0.2085C_R$ | | |
| SMNP #3H90104792 | 30-90 | $\theta = -0.2023 + 0.3835C_R$ | 110 - 150 | $\theta = 0.2708 + 0.0421C_R$ |

Results of the experiments showed that top yields at all project sites were reached for treatments 3 and 4 (Table 2), which were concluded as optimal and high moisture mode correspondingly. Treatments 1 and 2 were considered to be deficit scheduling of irrigations. Additional yield received at the optimal mode (75-75-60% of $F_C$) in comparison with the rigid scheduling of irrigation (65-65-60% of $F_C$) was as for: Tashkent, 0.98 t $ha^{-1}$ (24.4%); Khorezm, 0.77 t $ha^{-1}$ (21.9%); Syrdarya, 0.66 t $ha^{-1}$ (18.3%); and Kashkadarya, 1.53 t $ha^{-1}$ (50.5%).

## *Crop Water Use*

Winter wheat and sugar beet water use was measured by the soil water balance method. Considering ET as crop water use, P as precipitation, I as Irrigation, R as the sum of runoff and runon, F as flux across the lower boundary of the soil profile (control volume), and $\Delta S$ as change in soil water stored in the profile, we know that the soil water balance must sum to zero:

$$ET + \Delta S + R - P - I - F = 0 \qquad (1)$$

where the sign conventions are given in Evett[2] (1999) except for ET, which is taken here as positive when water is lost to the atmosphere through transpiration and/or evaporation. Re-arranging this equation gives the crop water use or ET as:

[2] Evett, S.R. Energy and Water Balances at Soil-Plant-Atmosphere Interfaces. Chapter 5, pp. A-129-A-182. In Malcolm E.Sumner (ed.) Handbook of Soil Science, CRC Press, Boca Raton, FL.

$$ET = -\Delta S + P + I - R + F \quad (2)$$

Table 2. Irrigation and productivity of winter wheat at four locations in Uzbekistan.

| # | Treatment (% $F_C$) | Irrigation, ($m^3$ $ha^{-1}$) | ET (mm) | Grain Yield (t $ha^{-1}$) | Water requirement per unit yield ($m^3$ $t^{-1}$) | Irrigation water use efficiency (kg $m^{-3}$) |
|---|---|---|---|---|---|---|
| | | | Tashkent | | | |
| 1 | 65-65-60 | 2100 | 425.9 | 4.01 | 5.24 | 1.91 |
| 2 | 70-70-60 | 2320 | 452.8 | 4.58 | 5.06 | 1.98 |
| 3 | 75-75-60 | 2420 | 466.7 | 4.99 | 4.85 | 2.06 |
| 4 | 80-80-70 | 2650 | 492.5 | 5.01 | 5.29 | 1.89 |
| | | | Khorezm | | | |
| 1 | 65-65-60 | 3450 | - | 3.52 | 9.80 | 1.02 |
| 2 | 70-70-60 | 3560 | - | 3.84 | 9.27 | 1.08 |
| 3 | 75-75-60 | 3690 | - | 4.29 | 8.60 | 1.16 |
| 4 | 80-80-70 | 3860 | - | 4.34 | 8.88 | 1.12 |
| | | | Syrdarya | | | |
| 1 | 65-65-60 | 2810 | - | 3.60 | 7.80 | 1.28 |
| 2 | 70-70-60 | 3150 | - | 4.16 | 7.57 | 1.32 |
| 3 | 75-75-60 | 3230 | - | 4.26 | 7.58 | 1.32 |
| 4 | 80-80-70 | 3400 | - | 4.34 | 7.83 | 1.28 |
| | | | Kashkadarya | | | |
| 1 | 65-65-60 | 2898 | - | 3.03 | 9.56 | 1.05 |
| 2 | 70-70-60 | 2930 | - | 3.61 | 8.11 | 1.23 |
| 3 | 75-80-70 | 2968 | - | 4.53 | 6.55 | 1.52 |
| 4 | 80-80-70 | 3131 | - | 4.46 | 7.02 | 1.42 |

Because of shallow water tables at Khorezm and Syrdarya, flux (F) across the lower boundary could not be considered negligible, and it was not possible to calculate the ET of the crops for those locations. It will be possible to measure ET if special weighing lysimeters are constructed at the Branch Stations of the Institute or elsewhere in Khorezm and Syrdarya.

The sum of runoff and runon (R) and the flux (F) were zero for automorphic soils of Tashkent Province and, therefore, the soil water balance equation gives the crop water use as:

$$ET = -\Delta S + P + I \quad (3)$$

Precipitation data (P) for Tashkent were taken from the weather station of the UNCGRI, which is located in the Central Experiment Station. During the wheat experiment (October, 2000 – June, 2001), the precipitation was 249 mm.

Values of change in soil water stored in the profile ($\Delta S$) were calculated with the use of the integral calculus method and data from Table 3.

Table 3. Volumetric water content of the old irrigated typical gray soil at the beginning and the end of vegetation (Tashkent, winter wheat)

| | Volumetric water content ($m^3$ $m^{-3}$) |
|---|---|
| At the beginning | Treatments of the experiment (% of $F_C$) |

| Soil layer (cm) | of vegetation | 65-65-70 | 70-70-60 | 75-75-60 | 80-80-70 |
|---|---|---|---|---|---|
| 30 | 0.250 | 0.174 | 0.205 | 0.202 | 0.205 |
| 50 | 0.250 | 0.206 | 0.206 | 0.240 | 0.230 |
| 70 | 0.250 | 0.215 | 0.233 | 0.250 | 0.251 |
| 90 | 0.260 | 0.232 | 0.240 | 0.248 | 0.272 |
| 110 | 0.250 | 0.275 | 0.265 | 0.275 | 0.300 |
| 130 | 0.270 | 0.288 | 0.262 | 0.294 | 0.307 |
| 150 | 0.290 | 0.309 | 0.277 | 0.296 | 0.320 |

Having calculated the ΔS for each treatment of the experiment, we determined the ET for the 0 to 150-cm deep soil control volume:

- Treatment 1, 65-65-60% of $F_C$: ΔS = 33.1 mm; ET = 249 + 210 – 33 = 426 mm
- Treatment 2, 70-70-60% of $F_C$: ΔS = 28.2 mm; ET = 249 + 232 – 28 = 453 mm
- Treatment 3, 75-75-60% of $F_C$: ΔS = 24.3 mm; ET = 249 + 242 – 24 = 467 mm
- Treatment 4, 80-80-70% of $F_C$: ΔS = 21.5 mm; ET = 249 + 265 – 22 = 492 mm

## *Sugar Beet*

Research was conducted with sugar beet in Tashkent (lysimeter experiment) and Khorezm (field experiment). Two irrigation scheduling treatments, 70-70-60% of $F_C$ (i) and 75-75-60% of $F_C$ (ii) were investigated, where the first two numbers (**70-70**-60% of $F_C$) are soil moisture levels used to trigger irrigations in the period of "germination to yield formation"; and the last number (70-70-**60**% of FC) is the soil moisture at which irrigations were applied during the period of "accumulation of sugar in the roots of sugar beet". Some experimental results on sugar beet are shown in Table 4.

Table 4. Irrigation and yields of sugar beet at Tashkent and Khorezm.

| # | Treatment (% $F_C$) | Irrigation ($m^3$ $ha^{-1}$) | ET (mm) | Yield | Sugar content, % |
|---|---|---|---|---|---|
| | | Tashkent | | | |
| 1 | 70-70-60 | 7500 | 681.1 | 5150 g/lys* | 15.7 |
| 2 | 75-75-60 | 8000 | 730.7 | 5545 g/lys | 15.3 |
| | | Khorezm | | | |
| 1 | 70-70-60 | 7560 | - | 4.20 t $ha^{-1}$ | 18.6 |
| 2 | 75-75-60 | 7740 | - | 4.65 t $ha^{-1}$ | 17.3 |

* grams per lysimeter

In Tashkent, sugar beet yields for treatment 2 (75-75-60% of $F_C$) were larger by 7.7% and sugar contents in the roots were less by 0.4% than for treatment 1 (70-70-60% of $F_C$). The same was true for the Khorezm field experiment.

Water use (ET) by sugar beet was 681 mm for treatment 1 of the Tashkent experiment and 731 mm for treatment 2. The ΔS values for Tashkent were: 85 mm for 70-70-60% of $F_C$ and 86 mm for 75-75-60 % of $F_C$. Precipitation during the sugar beet growing season (15 April 2001 – 15 September 2001) was 16.4 mm.

## *Conclusions:*

1. Preliminary results of the experiments with winter wheat and sugar beet carried out in various soil and climate conditions of Uzbekistan have shown that water content of the soil profile could be rapidly and accurately measured by soil moisture neutron probe (SMNP). The SMNP allows study of water content dynamics of soil profiles, determination of concrete data on water use, and scheduling of irrigations during cropping seasons.
2. Water use or ET of winter wheat and sugar beet were measured by the soil water balance method for the first time in Uzbekistan.
3. Experimental results of the first year of investigations showed that optimal development and high crop productivity of winter wheat and sugar beet at all project sites were reached when irrigations were scheduled at soil moisture levels of 75, 75, and 60% of field capacity during the three major crop growth stages, respectively. More irrigation did not result in additional yield from the crops.
4. The optimal scheduling of irrigation (75-75-60% of $F_C$) decreased the water requirement of winter wheat per unit of crop yield by 3.0 to 25.4% in comparison with scheduling of irrigation at 65-65-60% of $F_C$. At all project sites, comparatively high yields of winter wheat grain resulted from the optimal mode of irrigation scheduling (yield increases ranged from 18.3 to 50.5%).
5. When optimal irrigation scheduling was used, sugar beet productivity increased by 7.7% for lysimeters in Tashkent. In the Khorezm field experiment, this difference was 8.3% for the same treatments.

## *Acknowledgements*

We would like to thank all staff of the CRDF in Arlington and Moscow as well as other persons who were involved in selection, evaluation and support of our research proposal and quarterly reports on the Award ZB1-2050. Thanks to the CRDF Award ZB1-2050, the Uzbekistan team had the opportunity to conduct research in collaboration with USA scientists, received modern equipment and computers and learned new methods of investigations.

## CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION III A: FSU Team Data**
*(to be completed by the FSU Principal Investigator only)*

**Award Number: ZB1-2050**

### A. Research Information

1. **Scientific Results**

a. Were the scientific and technical objectives of your original proposal accomplished?

**Yes**: ✔ No ☐

b. If specific research objectives were *not* accomplished, please briefly describe the factors that impeded their successful completion (e.g., unanticipated research results, difficulty in communications, administrative or financial complications, etc.).

c. If specific research objectives were *changed*, please describe:

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2. **Collaborative Benefits**

a. Describe the benefits of having conducted your research in collaboration with U.S. counterparts rather than independently.

- ✔ Exchange of ideas
- ✔ Access to new facilities
- ✔ Joint publications
- ✔ Access to new research methods
- ☐ Other (please describe)
- ✔ Complementary expertise in particular research area
- ✔ Access to new or previously unavailable information
- ☐ Access to new geographical research area
- ✔ Educational effect on young researchers/students

b. Describe any difficulties related to the collaborative nature of the effort.

- ✔ Language barriers
- ✔ Procuring equipment or supplies
- ☐ Other time commitments
- ☐ Travel/Visas
- ☐ Other (please describe)
- ☐ E-mail/Internet difficulties
- ☐ Paperwork
- ☐ Intellectual Property Rights issues
- ☐ Financial Issues

c. Will the collaboration with the US team continue? **Yes**: ✔ No ☐

d. If "Yes", by which of the following means? (check all that apply)

- ✔ Future joint publications
- ☐ Joint patents
- ✔ E-Mail contact
- ✔ New grant proposals
- ☐ Exchange visits
- ☐ Other (please describe)

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**3. Additional Support**

a. Do you feel your work on this project helped to enable <u>you or your research group</u> to obtain support from sources other than CRDF? **Yes**: ✔ No ☐

b. If "Yes", check sources (check all that apply).

- ☐ ISTC/STCU
- ☐ INTAS
- ☐ NATO
- ☐ US Department of Energy (DOE)
- ☐ Russian Foundation for Fundamental Research (RFFI)
- ✔ FSU Government Agency/Ministry
- ☐ Howard Hughes Medical Institute (HHMI)
- ✔ Other (please identify): IAEA

c. In the future, do you plan to apply for support for continuation of your collaborative research from sources other than CRDF? **Yes** ✔ No ☐

- ☐ ISTC/STCU
- ☐ INTAS
- ☐ Russian Foundation for Fundamental Research (RFFI)
- ✔ FSU Government Agency/Ministry

☐ NATO
☐ US Department of Energy (DOE)
☐ Howard Hughes Medical Institute (HHMI)
✓ Other (please identify): USDA/OICD

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4. **Technology Commercialization**

a. Are you pursuing commercial application of your research results? Yes ☐ **No** ✓

b. If "Yes", please check all that apply:

☐ Planning joint patent application
☐ Approved joint patent application
☐ Contract with for-profit company
☐ Marketing
☐ Other: (please describe)
☐ Planning country-specific patent application
☐ Approved country-specific patent application
☐ Prototype development
☐ Manufacturing

---

5. **Transition to Civilian Science**

a. Did your project include researchers who were formerly actively engaged in defense-related research? Yes ☐ **No** ✓ (*if you check No, please skip to Question 6*)

b. Did the CRDF research project provide a positive means for engaging and retaining former defense scientist(s) in civilian science? Yes ☐ **No** ✓

c. If Yes, please describe:

d. Did any of the former defense researchers on your team change institutional affiliation or country of residency during this project? Yes ☐ **No** ✓

e. If Yes, please describe:

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6. **Research Infrastructure**

a. During what percentage of your work day do you have direct personal access to a computer with Internet and e-mail capability?

Less than 25% ☐ 25% ☐ 50% ☐ **100%** ✓ I do not have access ☐

b. How did you use technological information resources (such as the Internet, e-mail) to support your CGP project? (check all that apply)

✓ To obtain data or information
✓ To consult with co-investigator by e-mail
✓ To consult with other researchers working on the same or related topics by e-mail
☐ To identify future research collaborators
✓ To identify funding sources
☐ To promote/market the results of the research project
☐ Other (please describe)

c. Over the course of the award, did you or your laboratory/institute develop new linkages (international or in-country) with any of the following in order to carry out the research project (check all that apply)?

☐ Academy of Sciences Research institutions
✓ Government Research Institutions
☐ Universities

☐ For-Profit Companies
✔ Other (please describe) IAEA (TC Department of the International Atomic Energy Agency)
USDA (International Unit of the USDA)

d. Please briefly identify and describe the institutional linkages developed (e.g., "developed arrangement to share access to research equipment with XXX Institute"):
*Developed arrangement to share access to research equipment with the Research Institute of Veterinary, Samarkand, Uzbekistan.*

e. Over the course of the award, did you have the opportunity to utilize equipment (for project-related purposes) at your U.S. collaborator's institution or other foreign or FSU institutions?
**Yes**: ✔ No ☐

If "Yes", please describe: 1. Water Management Research Unit, Production & Conservation Lab, Bushland, TX, USA (SMNP)
2. Agriculture Faculty, Cukurova University, Adana, Turkey (SMNP, Tensiometers)

## B. Administrative Information

1. **Project Personnel**
a. List all members of your CGP research team (including those who worked on the project but did not receive individual financial support from CRDF) including name, date of birth, gender, and affiliation (if different from Principal Investigator's institution). Please include and identify students. Please identify as "Former Defense Researchers" those project participants who were formerly or are currently actively engaged in research at a current or former defense laboratory or institution. *For those researchers only*, please indicate the type of defense-related research by using the code list provided in the Appendix.

| # | Name/Institutional Affiliation | Date of Birth (MM/DD/YYYY) | Gender [M/F] | Student? | Former Defense Researcher? | Defense Code (see Appendix for code) |
|---|---|---|---|---|---|---|
| 1 | Nazirbay Ibragimov<br>UNCGRI, Tashkent | 11.19.1959 | M | No | No | |
| 2 | Bakhtiyor Kamilov<br>UNCGRI, Tashkent | 08.21.1950 | M | No | No | |
| 3 | Yusupbek Esanbekov<br>UNCGRI, Tashkent | 05.02.1948 | M | No | No | |
| 4 | Maksudbek Sarimsakov<br>UNCGRI, Tashkent | 12.05.1967 | M | Yes | No | |
| 5 | Jamaliddin Shadmanov<br>UNCGRI, Syrdarya | 11.30.1962 | M | No | No | |
| 6 | Bakhrom Mukhamadiev<br>UNCGRI, Khorezm | 06.15.1971 | M | Yes | No | |
| 7 | Tilak Radjabov<br>UNCGRI, Kashkadarya | 02.05.1945 | M | No | No | |

b. Did any of the participating students complete a thesis in whole or in part based on research directly related to the CRDF-sponsored project? **Yes**: ✔ No ☐

c. If "Yes", check all that apply: Doctoral/**Candidat** ✔ ☐ Undergraduate

2. **Project-Related Travel**

| | |
|---|---|
| a. How many FSU team members traveled to the United States for | One person |

| | |
|---|---|
| project-related purposes during the term of the grant? | |
| b. Of these, how many were students? | None |
| c. How many FSU team members traveled to countries other than the U.S. for project-related purposes such as presenting CGP research results at an international conference? | Supposed, one person |
| d. Of these, how many were students? | None |
| e. How many FSU team members left the FSU for six months or more during the grant period to take a position in a foreign laboratory or organization? | None |
| f. Of these, how many were students? | None |

**3. Award Administration**

a. Did you encounter any administrative difficulties during the course of the project?

Yes ☐ **No** ✓

b. If "Yes", please identify the type of problem encountered by checking the appropriate box below (check all that apply).

☐ Individual financial support payments
☐ Purchase of materials & services
☐ Institutional support payments
☐ Travel /Visa Issues
☐ Cost-share payments
☐ Communication with CRDF staff

☐ Other (please describe)

c. Please comment on how these difficulties were addressed and/or resolved.

4. **CRDF Performance**

On a scale of 1 to 5, rate the performance of CRDF staff in administering your award. (If there are specific instances of poor performance or instances of excellent performance, please provide a brief explanation.)

| *Poor* | | *Good* | | *Excellent* |
|---|---|---|---|---|
| 1 ☐ | 2 ☐ | 3 ☐ | **4** ✓ | 5 ☐ |

Explanation:

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION III B: FSU Final Reconciliation and Confirmation**
*(to be completed by the FSU Principal Investigator only)*

**Award Number: ZB1-2050**
***** Section III B must be completed, printed, signed, and faxed to CRDF at 703-526-9721. *****

1. **Total Amounts Received:**

| Please indicate the total amount received from CRDF in support of this project. | |
|---|---|
| Expense Categories | Amount Received from CRDF |
| Individual Financial Support | $17,550.00 |
| Materials and Services | $13,313.80 |
| Travel Expenses | $ 3,206.32 |
| Institutional Support | $10,126.57 |
| Subcontracts | $ 0.00 |
| TOTAL | $44,196.00 |

| Please indicate the total amount received from FSU Government costshares (as indicated in your CRDF Award Notice) | | |
|---|---|---|
| Expense Category | Amt. In Local Currency | Amount in USD |
| Individual Financial Support | 2,859,100.00 | $7,147.75 |
| Materials & Services | 565,000.00 | $1,412.00 |
| Travel Expenses | 514,000.00 | $1,285.00 |
| Institutional Support | 2,692,500.00 | $6,731.00 |
| Subcontracts | 0.00 | $ 0.00 |
| Other Project Expenses | 0.00 | $ 0.00 |
| TOTAL | 6,630,600.00 | $16,575.75 |

2. **Institutional Support:** Please indicate how the institutional support component of the award was used to support the project.

| Expense Type | Amount (US$) |
|---|---|
| Individual Financial Support | $ 0.00 |
| Materials and Services | $ 8,524.01 |
| Internet Connection/Access | $ 96.50 |
| Communications Costs (telephone, fax, etc.) | $ 225.33 |
| Utilities (such as heat, electricity, etc.) | $ 228.10 |
| Administrative/Clerical Support | $ 0.00 |
| Publications | $ 400.00 |
| Travel Expenses | $ 241.72 |
| Equipment maintenance/repair | $ 0.00 |
| Facilities upgrades/repair | $ 416.49 |
| Other: | $ 0.00 |
| TOTAL | $10,132.15 |

3. **Amount Received from Other Sources:** This refers to any monetary or material support you received as additional support for research relating to this project from sources not included in the amount awarded by CRDF in your original award documents. Funds from CRDF or from FSU Government cost-share commitments *should not* be noted here. Please complete the table below for each source of support. Copy the table as necessary.

| SOURCE: IAEA TC Project UZB/5/002 | | |
|---|---|---|
| Expense Category | Amt. In Local Currency | Amount in USD |
| Individual Financial Support | | $ 0.00 |
| Materials & Services | | $ 40,000.00 |
| Scientific visits + Fellowships | | $ 45,000.00 |
| Institutional Support | | $ 0.00 |
| Subcontracts | | $ 0.00 |
| Other Project Expenses (Experts) | | $ 20,000.00 |
| TOTAL | | $105,000.00 |

4. Did you and your team members receive **CRDF funds** in full and with no taxes withheld?
   **Yes** ✓ No ☐

**FINAL CERTIFICATION**

We hereby certify that the information provided in this report is complete and accurate to the best of our knowledge and belief and that all work performed under this project supported by CRDF funds was carried out in accordance with the Award General Conditions.

Signature of FSU Principal Investigator Date

Signature of Authorized Institutional Representative & Institutional Seal Date

***** Section III B must be completed, printed, signed, and faxed to CRDF at 703-526-9721. *****

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION IV A: US Team Data**
*(to be completed by the US Principal Investigator only)*

**Award Number: ZB1-2050**

## A. Research Information

1. **Scientific Results**

a. Were the scientific and technical objectives of your original CGP proposal accomplished?
Yes ✔ No ☐

b. If specific research objectives were not accomplished, please describe the factors that impeded their successful completion (e.g., unanticipated research results, difficulty in communications, administrative or financial complications, etc.).

c. If specific research objectives were changed, please describe:

2. **Collaborative Benefits**

a. Describe the benefits of having conducted your research in collaboration with FSU counterparts rather than independently.

- ✔ Exchange of ideas
- ✔ Access to new facilities
- ✔ Joint publications
- ✔ Access to new research methods
- ☐ Other (please describe)
- ✔ Complementary expertise in particular research area
- ✔ Access to new or previously unavailable information
- ✔ Access to new geographical research area
- ✔ Educational effect on young researchers/students

b. Describe any difficulties related to the collaborative nature of the effort.

- ✔ Language barriers
- ✔ Procuring equipment or supplies
- ☐ Other time commitments
- ☐ Travel/Visas
- ☐ Other (please describe)
- ☐ E-mail/internet difficulties
- ☐ Paperwork
- ☐ Intellectual Property Rights issues
- ☐ Financial Issues

c. Will your collaboration with the FSU team continue? Yes ✔ No ☐

d. If "Yes," by which of the following means? (please check all that apply)

- ✔ Future joint publications
- ☐ Joint patents
- ✔ E-Mail contact
- ✔ New grant proposals
- ☐ Exchange visits
- ☐ Other (please describe)

3. **Additional Support**

a. Do you feel your work on this project helped to enable you or your institution to obtain support for continuation of your collaborative research from sources other than CRDF? Yes ☐ No ✔

b. If "Yes," list sources:

c. In the future, do you plan to apply for support for continuation of your collaborative research from sources other than CRDF? Yes ✔ No ☐

d. If "Yes," list potential sources: **USDA/OICD, State Department**

**4. Technology Commercialization**

a. Are you pursuing commercial application of your research results? Yes ☐ No ✔

b. If "Yes," please check all that apply:

☐ Planning joint patent application
☐ Approved joint patent application
☐ Contract with for-profit company
☐ Marketing
☐ Other (please describe)
☐ Planning country-specific patent application
☐ Approved country-specific patent application
☐ Prototype development
☐ Manufacturing

## B. Administrative Information

1. **Project Personnel**

List all U.S. members of your CGP research team including name, age, gender, and affiliation (if different from Principal Investigator's institution). Include and identify students, even if not paid.

| # | Name/Institutional Affiliation | Date of Birth (MM/DD/YYYY) | Gender [M/F] | Student? |
|---|---|---|---|---|
| 1 | **Steven R. Evett** | **04/13/1948** | **M** | N |
| 2 | **Sheen T. Kottkamp** | **03/06/1975** | **M** | Y |
| 3 | | | | ☐ |
| 4 | | | | ☐ |
| 5 | | | | ☐ |
| 6 | | | | ☐ |
| 7 | | | | ☐ |
| 8 | | | | ☐ |
| 9 | | | | ☐ |
| 10 | | | | ☐ |

2. **Project-Related Travel**

| | |
|---|---|
| a. How many U.S. team members traveled to the FSU for project-related purposes during the term of the grant? | 1 |
| b. Of these, how many were students? | 0 |
| c. How many U.S. researchers traveled to non-FSU countries for project-related purposes such as presenting CGP research results at an international conference? | 1 |
| d. Of these, how many were students? | 0 |

**3. Award Administration**

a. Describe any administrative difficulties encountered during the course of the CGP grant.

☐ Graduate student stipend payments
☐ Purchase of materials and services
☐ Cost-share payments
☐ Travel/Visa Issues
☐ Communication with CRDF staff
☐ Other (please describe)

b. Please comment on how these difficulties were addressed and/or resolved.

---

4. **CRDF Performance:** On a scale of 1 to 5, rate the performance of CRDF staff in administering your award. (If there are specific instances of poor performance or instances of excellent performance, please provide a brief explanation.)

| *Poor* | | *Good* | | *Excellent* |
|---|---|---|---|---|
| 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ✔ |

Comments: From my point of view, the performance of CRDF was admirable. I've had far more problems with some other overseas projects.

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION IV B: US Final Reconciliation and Confirmation**
*(to be completed by the US Principal Investigator only)*

**Award Number: ZB1-2050**

***** Section IV B must be completed, printed, signed, and faxed to CRDF at 703-526-9721. *****

## FINANCIAL REPORTING

(1) The U.S. institution should submit a final financial report detailing all costs incurred and funds received from CRDF for the project. This report should be attached to this certification or may be submitted by mail to CRDF's Arlington Office along with item (2) below.

We received a total of $13,600.00. We have expended the total amount in support of the project as follows:

| | |
|---|---|
| Travel, per diem and related expenses for Steve Evett's travel to Uzbekistan: $8,462.00 | |
| Support of Sheen Kottkamp, graduate student at West Texas A&M University: | $4,138.00 |
| Materials and supplies: | $1,000.00 |
| Total: | $13,600.00 |

(2) Please provide a recent copy of your organization's federal audit report (e.g., A-133), if available.

## FINAL CERTIFICATION

We hereby certify that the information provided in this report is complete and accurate to the best of our knowledge and belief and that all work performed under this project supported by CRDF funds was carried out in accordance with the Award General Conditions.

Steven R. Evett January 10, 2002
Signature of US Principal Investigator Date

R. Nolan Clark January 10, 2002
Signature of Authorized Institutional Representative Date

***** Section IV B must be completed, printed, signed, and faxed to CRDF at 703-526-9721. *****

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION V: Bibliography of Project-Related Publications**

**Award Number: ZB1-2050**

## BIBLIOGRAPHY OF PROJECT-RELATED PUBLICATIONS

Evett, S.R. 2001. "Exploits and Endeavors in Soil Water Management and Conservation Using Nuclear Techniques". *In* Proceedings of The International Symposium on Nuclear Techniques in Integrated Plant Nutrient, Water and Soil Management. Vienna, Austria, 16-20 October (2000) International Atomic Energy Agency, Vienna, Austria.

Evett, S.R., Ibragimov, N., Kamilov, B., Esanbekov, Y., Sarimsakov, M., Shadmanov, J., Mukhamadiev, B., Radjabov, T. "Soil Moisture Neutron Probe Calibration and Use in Four Soils of Uzbekistan". Accepted for publication *In* Proceedings of The 17th World Congress of Soil Science, August 14-21, (2002), Bangkok, Thailand

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

**SECTION VI: Conference Presentation List**

**Award Number: ZB1-2050**

**LIST OF PROJECT-RELATED CONFERENCE PRESENTATIONS**

- Evett, S.R. 2001. Exploits and Endeavors in Soil Water Management and Conservation Using Nuclear Techniques (Oral Presentation). International Symposium on Nuclear Techniques in Integrated Plant Nutrient, Water and Soil Management. International Atomic Energy Agency, 16-20 October 2000, Vienna, Austria.

- Evett, S.R., Ibragimov, N., Kamilov, B., Esanbekov, Y., Sarimsakov, M., Shadmanov, J., Mukhamadiev, B., Radjabov, T. "Soil Moisture Neutron Probe Calibration and Use in Four Soils of Uzbekistan", (Poster Presentation), 17th World Congress of Soil Science, August 14-21, 2002, Bangkok, Thailand.

# CRDF COOPERATIVE GRANTS PROGRAM: FINAL PROJECT REPORT

## SUPPLEMENTAL INFORMATION (optional)

**Award Number: ZB1-2050**

CRDF appreciates receiving supplemental information, such as **photographs, publicity articles, publication copies, Power Point presentations, or other materials.** Please send such materials directly to the CRDF contacts listed in the General Instructions on page 2.

If you submit photographs, please be sure to identify all persons pictured and indicate their roles in the CRDF project. Please be aware that unless you indicate otherwise, CRDF reserves the right to use photographs and other materials above in publicly-distributed CRDF documents.

Thank you.