ADB TA 6357: Central Asian Countries Initiative for Land Management Multi-country Support Project

CACILM Multicountry Partnership Framework Support Project on

Sustainable Land Management Research

ADB TA 6357

Training course on "The NDVI sensor, toward the integrated evaluation of crop management"

(August 6, 2008- August 13, 2008)

Organisers: ICARDA, ZEF-UNESCO, CIMMYT

ICARDA

International Center for Agricultural Research in the Dry Areas

CAC Regional Office, Tashkent, Uzbekistan

Venue: Urgench State University, Uzbekistan

List of Participants

##	Name	Organization
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4	Mr. Safarov Hasan	Tajikistan Soil Science Research Institute
5	Mr. Hemra Charyev	National Institute of Desert's, Flora and Fauna Ministry of Nature Protection of Turkmenistan
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7	Narziev Jasurbek	SANIIRI, Central Asian Scientific Research Institute of Irrigation, Uzbekistan
8	Prof. Ibragimov Nazar	ZEF/UNESCO-Project, Uzbekistan
9	Dr. Egamberdiev Oybek	ZEF/UNESCO
10	Mr. Sultanov Murad	ZEF/UNESCO
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13	Mr. Erkin Ruziboev	ZEF/UNESCO
14	Ms. Jamila Haitbaeva	ZEF/UNESCO
15	Ms. Mina Devkota	ZEF/UNESCO
16	Mr. Krishna Devkota	ZEF/UNESCO
17	Ms. Yulduzoy Djumaniyazova	ZEF/UNESCO
18	Ms. Oksana Forkutsa	ZEF/UNESCO
19	Dr. Raj Gupta	ICARDA-CAC Tashkent
20	Mr.Yuldashev Tulkun	ICARDA-CAC Tashkent

Objectives:

- Training for trainers
- WORKshop

- Principles on integrated evaluation of cropping systems
  - What would you do with it!
  - How to apply in your research
- Learn to take home and develop
  - Presentation of your results
  - Future plans
- The program will enhance understanding of the use and application of evaluation tool for the integrated evaluation of cropping systems
- Participants will develop the skills necessary to monitor soil and plant parameters as they relate to cropping management systems, as well as their influence on physical, chemical and biological soil quality, their effect on climate change adaptation and mitigation, and their impact on water and nutrient use efficiency.
- Participants will strengthen their ability to synthesize and apply the information and knowledge related to conservation agriculture technologies
- Information of other CIMMYT scientists
- Deliverable – presentation of results - future

Program workshop

Delivered presentation by Bram Govaerts:

- SESSION 1a The NDVI sensor: Introduction
- SESSION 1b Introduction – Conservation Agriculture (CA)
- SESSION 1c Introduction - General
- SESSION 2 Nitrogen Prediction
- SESSION 3 Understand crop management
- SESSION 4 Spatial Variability
- SESSION 5 Other uses of the greenseeker
- SESSION 6 Soil quality

Materials handed out

- CD
    - Presentations
    - Publications
    - Further readings
    - The Greenseeker NDVI sensor Integrated evaluation - User Manual
    - The Greenseeker NDVI sensor Integrated evaluation - Course Material
    - Macro

Outputs:

1. Results of the past research
    a. NDVI for Nitrogen management
       Datasets were analyzed for the following systems Uzbekistan-Irrigated winter wheat; Kyrgystan -Rainfed winter wheat, Turkmenistan-Irrigated winter wheat
        i. INSEY ~Crop Yield- relation determined
        ii. RI ndvi ~RI yield relation determined
        iii. Amount N to be added ~NUE- relation determined
        iv. %N in grains
        v. Calculator (Algorithm) for the prediction of nitrogen application requirements developed
    b. Other possibilities for using NDVI calculation with Greenseeker
        i. Use of sensor for Chickpea varieties
        ii. Use of sensor for prediction of N application at cotton field
2. Future plans
    a. NDVI for Nitrogen management
    b. Other uses of the Greenseeker
3. Field day – Presentation of lessons learned during field day

Uzbekistan-Irrigated winter wheat

i. INSEY ~Crop Yield- relation

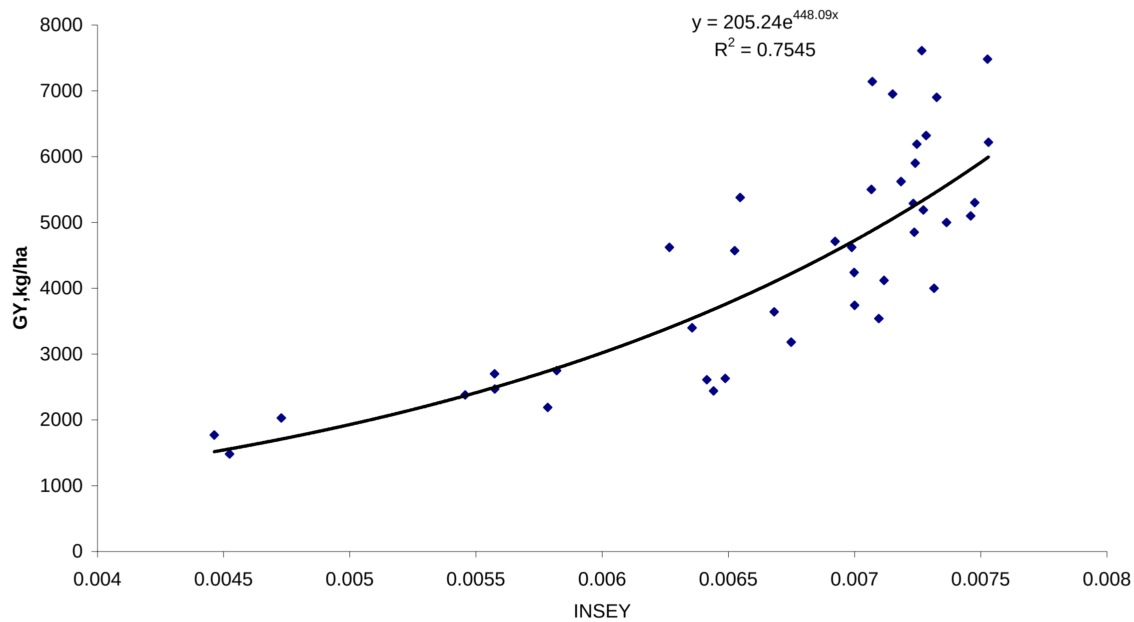

Figure 1 INSEY-Crop yield relation in Uzbek Cotton Growing Institute experimental site

ii. RI ndvi ~RI yield relation

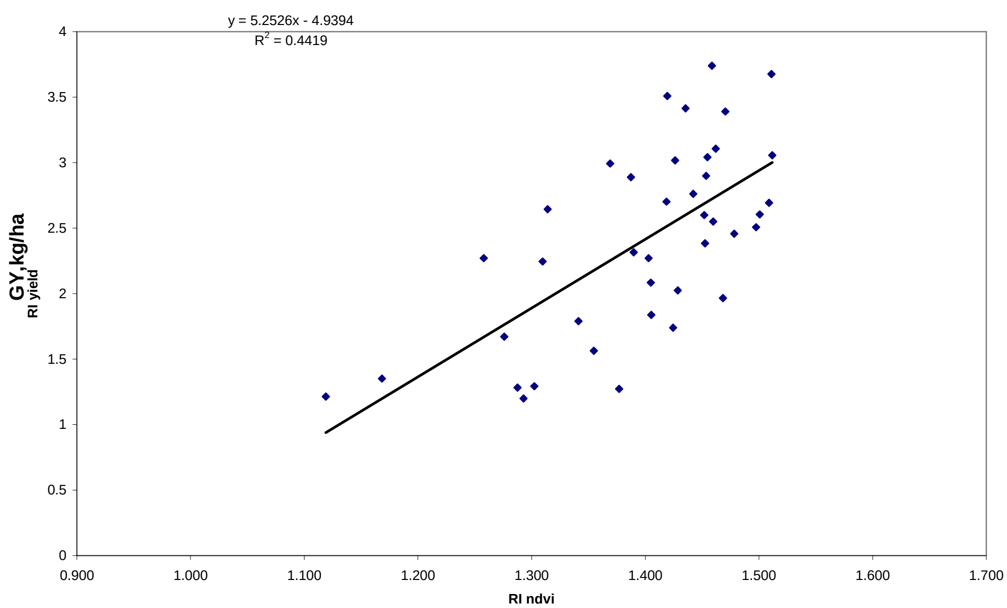

Figure 2 RI ndvi ~RI yield relationship obtained from Uzbek Cotton Growing (UCGRI) Institute site

iii. Amount N to be added ~NUE- relation

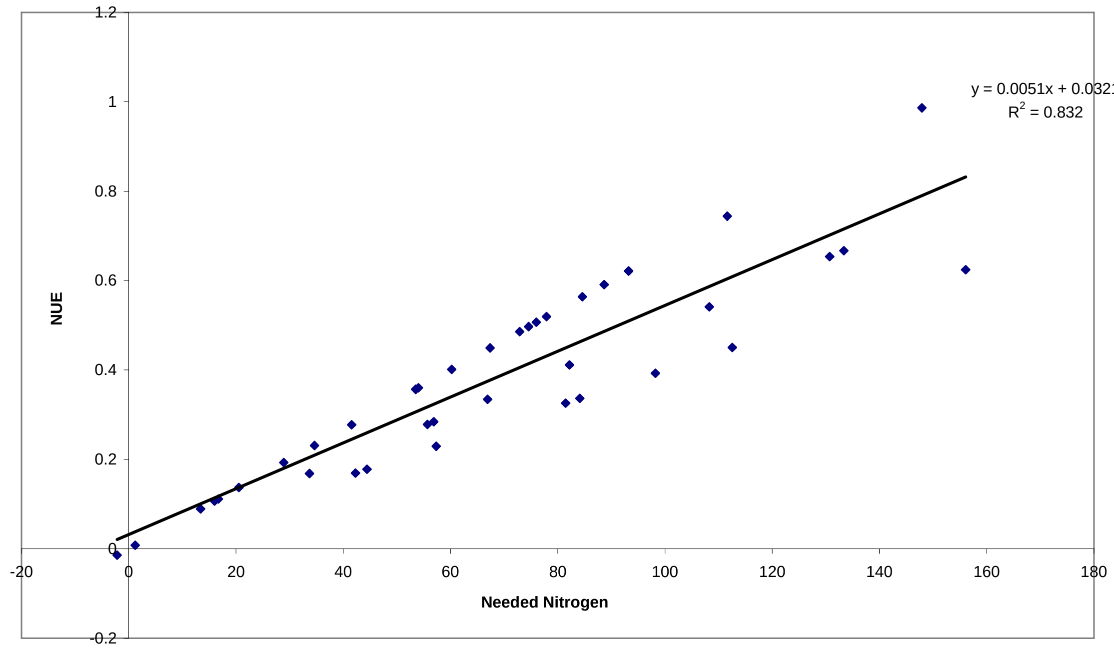

Figure 3 Correlation between amount of Nitrogen needed and NUE from UCGI site

Comments:

1. High correlation was found between INSEY and YIELD, RIndvi and RI yields and Nitrogen needed and NUE. The same experiment to be continued in 2007-2008.
2. Data to be cleaned after NDVI measurements using macro file.
3. Experimental design to be changed. The experimental subplots to be separated with protection border after each 1 line in order to avoid interferences from another N applied subplots.

Calculator

The calculator (Table 1) is ready to be used in validation, so we plan to select 5 winter wheat planted farmers fields, where farmers willing to follow our recommendation how much N to be applied at F6 stage using Green seeker at the UCGI site, while we continue with the calibration experiment in order to further improve the calculator.

Table 1 Calculator for prediction of N requirements at Uzbek Cotton Growing Experimental site

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7	STEP 8	STEP 9	STEP 10	STEP 11	STEP 12	STEP 13
Enter Plot NDVI	Enter number of days from planting where GDD>0	Compute INSEY = NDVI/ Days, GDD>0	Compute **YPo** **YPo**= 205,24*exp(448.09*INSEY)	Determine **Rindvi** **RI**=NDVI (Nitrogen Rich Strip)/NDVI (farmer check)	Riyield **Riyield(=Y) = 3.59 Rindvi(=X) - 2.38**	Compute **YPn** **YPn**=YPo * RI	YPmax determined by agronomist (YPn cannot exceed YPmax) **YPn(cap)<= 7000 kg/ha**	Determine Grain N uptake at **YPo** GNUP_YPo = YPo in kg/ha * 0.0239	Determine Grain N uptake at **YPn** GNUP_YPn = **YPn** in kg/ha * 0.0239%	Compute N needed=GNUP_YPn — GNUP_Ypo	NUE=0,0051 N needed + 0,0321	Detemine fertilizer N requirement FNR = (GNUP_YPn - GNUP_YPo)/0.5043
NDVI	**GDD**	**INSEY**	**YPo, kg/ha**	**RI ndvi**	**RI yield**	**YPn, kg/ha**	**YPn(cap), kg/ha**	**GNUP_YPo**	**GNUP_YPn**	**N needed**	**NUE**	**FNR, kgN/ha**
0.655	122	0.00537	2275.4	1.3	2.3	5185.1	5185.1	54.4	123.9	69.5	0.39	178.3
0.643	122	0.00527	2177.3	1.3	2.4	5150.9	5150.9	52.0	123.1	71.1	0.39	182.2
0.624	122	0.00511	2030.5	1.4	2.5	5097.1	5097.1	48.5	121.8	73.3	0.41	187.9
0.634	122	0.0052	2106.5	1.3	2.4	5125.3	5125.3	50.3	122.5	72.1	0.40	184.9
0.687	122	0.00563	2559.2	1.2	2.1	5276.4	5276.4	61.2	126.1	64.9	0.36	166.5
											0.4	179.9
NDVI Rich Strip =	0.85											
NUE	39%											

Kyrgyzstan-Irrigated winter wheat

iv. INSEY ~Crop Yield- relation

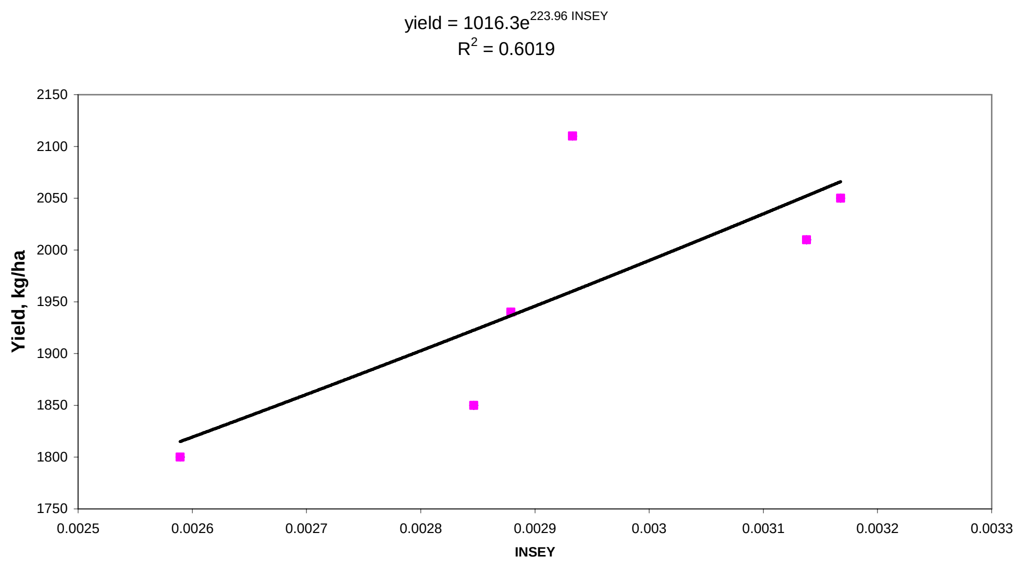

Figure 4 Correlation between INSEY and Crop yields at Kyrgyzstan experimental site

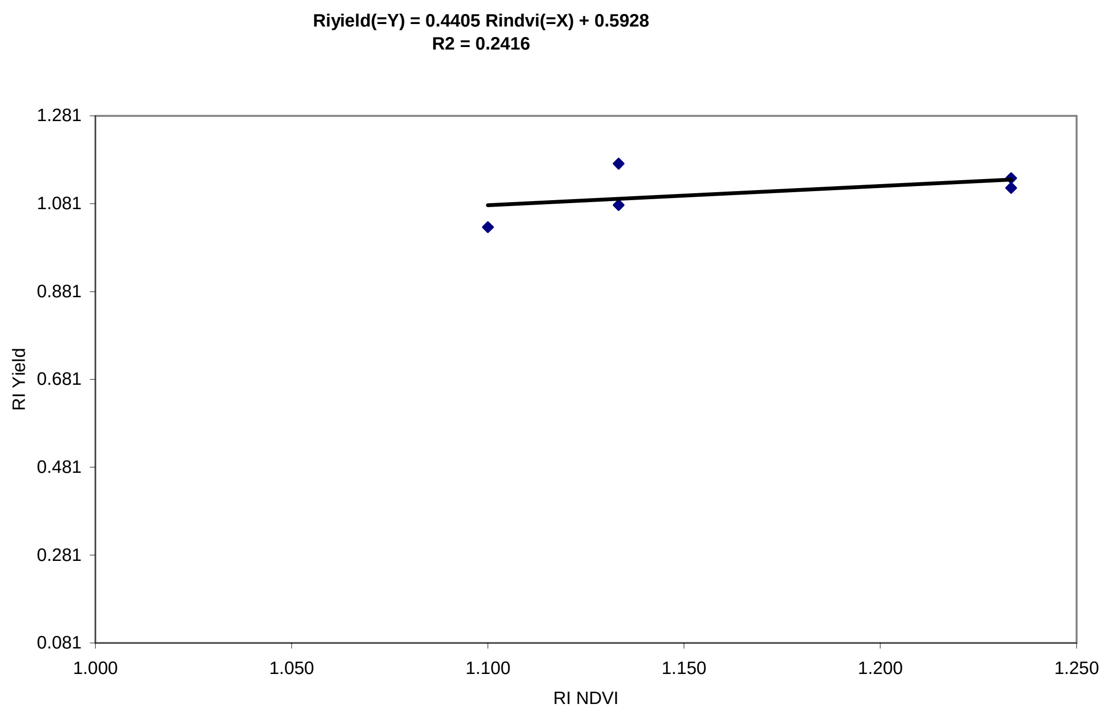

Figure 5 Correlation between RIndvi and RI yields at Kyrgyzstan experimental site

Table 2 Calculator for prediction of N requirements at Kyrgyzstan Experimental site

STEP 1	STEP 2	STEP 3	STEP 4		STEP 5	STEP 6	STEP 7	STEP 8	STEP 9		STEP 10
Enter Plot NDVI	Enter number of days from planting where GDD>0	Compute INSEY	Compute **YPo**	Determine **Rindvi**	Riyield	Compute **YPn**	YPmax determined by agronomist (YPn cannot exceed YPmax)	Determine Grain N uptake at **YPo**	Determine Grain N uptake at **YPn**		Detemine fertilizer N requirement
		= NDVI/ Days, GDD>0	**YPo**= 1016.3* exp(223.96* INSEY)	**RI**=NDVI (Nitrogen Rich Strip)/NDVI (farmer check)	**Riyield(=Y) = 0.4405 Rindvi(=X) + 0.5928**	**YPn**=YPo * RI	**YPn(cap)**<= 5000 kg/ha	GNUP_YPo = YPo in kg/ha * 0.0239	GNUP_YPn = **YPn** in kg/ha * 0.0239%		FNR = (GNUP_YPn - GNUP_YPo)/0.5043
NDVI	**GDD**	**INSEY**	**YPo, kg/ha**	**RI ndvi**	**RI yield**	**YPn, kg/ha**	**YPn(cap), kg/ha**	**GNUP_YPo**	**GNUP_YPn**	**N needed**	**FNR, kgN/ha**
0.3	102	0.00294	1963.8	1.7	1.3	2604.2	2604.2	46.9	62.2	15.3	76.5
0.33	102	0.00324	2097.5	1.5	1.3	2641.7	2641.7	50.1	63.1	13.0	65.0
0.4	102	0.00392	2446.0	1.3	1.1	2795.3	2795.3	58.5	66.8	8.3	41.7
0.35	102	0.00343	2191.7	1.4	1.2	2676.8	2676.8	52.4	64.0	11.6	58.0
0.36	102	0.00353	2240.3	1.4	1.2	2697.1	2697.1	53.5	64.5	10.9	54.6
NDVI Rich Strip =	0.5									***Average N***	59.2
NUE	20%										

Calculator

This calculator can not be used because of the mistakes in the raw data. We need extra calibration data to develop a realistic calculator and before going to validation.

Comments:

1. In spite of good correlation was found between INSEY and YIELD there is only few (6) measurements of crop yields collected in the experimental site, which is not sufficient to prove strong relation between 2 parameters. NDVI and Crop yields data to be collected from each replication and each furrow to get better results.
2. Low correlation between RIndvi and RI yields proves above comments
3. The same experiment to be continued in 2007-2008.
4. Since crop yields doesn't much effected with higher application doses of Nitrogen to be applied with narrow window (0,30,60,90,120)
5. Data to be cleaned after NDVI measurements using macro file.

Turkmenistan-Irrigated winter wheat

v. INSEY ~Crop Yield- relation

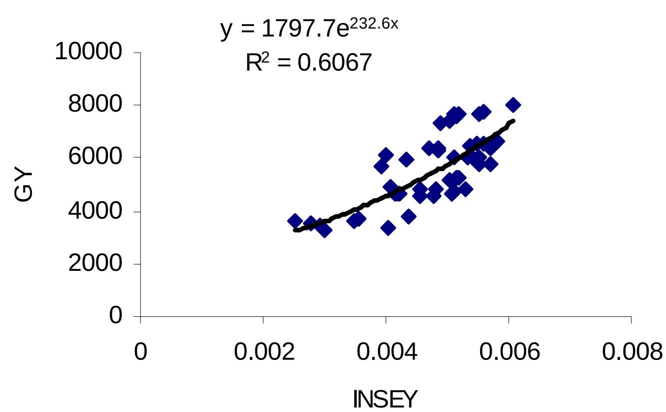

Figure 6 **INSEY-Crop yield relation in Turkmenistan experimental site**

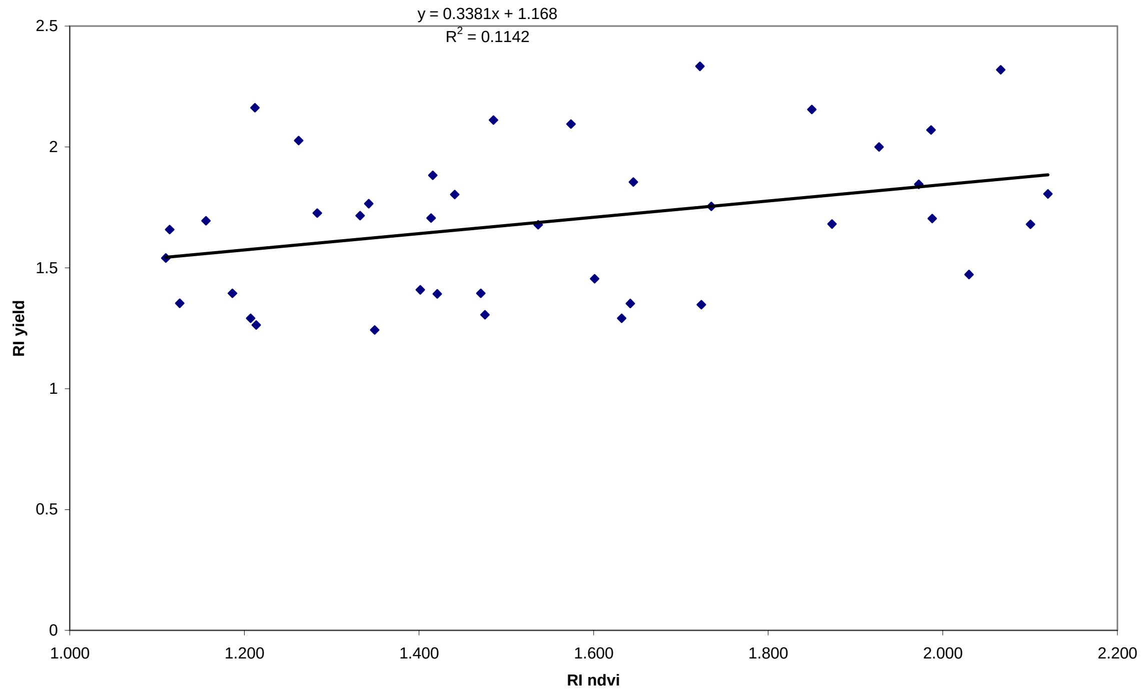

Figure 7 Correlation between RIndvi and RI yields at Turkmenistan experimental site

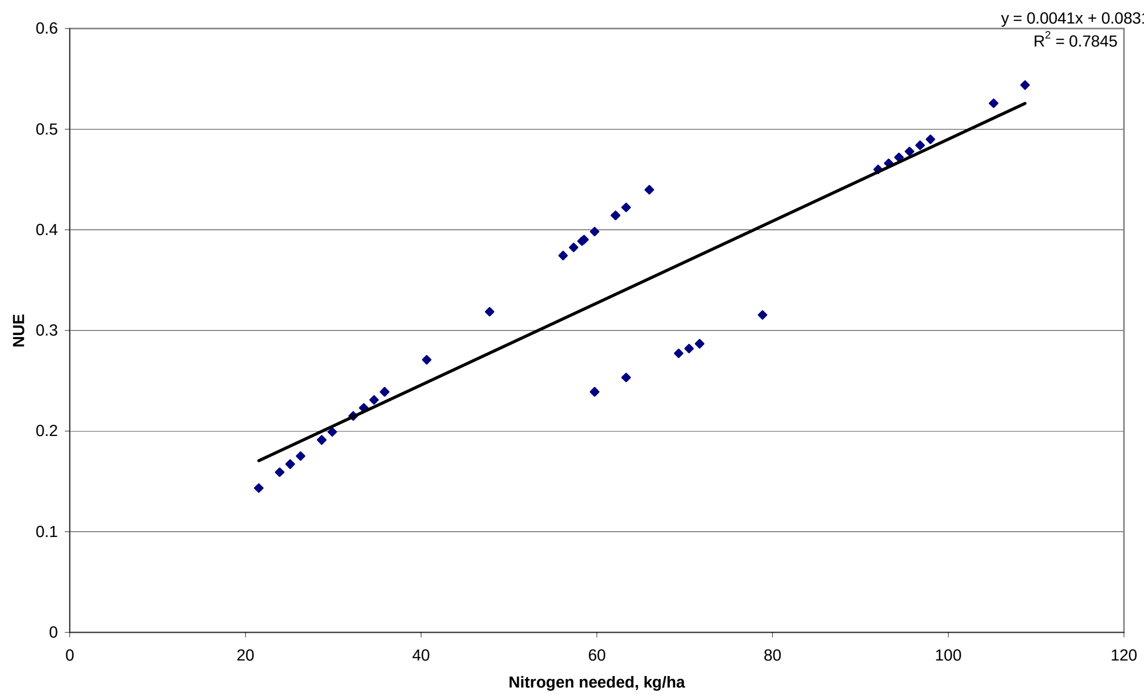

Figure 8 Correlation between amount of Nitrogen needed and NUE from Turkmenistan site

Calculator

This calculator can be used only after checking of all raw NDVI and crop yield data collected during first year of experiment. We need extra calibration data before going to validation.

Comments:

1. Data collected from the calibration experiments are not very reliable
2. In spite of good correlation between INSEY and YIELD, the correlation for RIndvi and RI yields is very weak.
3. NDVI and Crop yields data to be collected from each replication and each furrow to get better results.
4. The same experiment for calibration with different rates of Nitrogen at the site to be continued in 2007-2008.
5. Final decision for selecting farmers' fields in order to make validation of first year calculator could be drawn only after checking of the row data
6. Data to be cleaned after NDVI measurements using macro file.

Table 3 Calculator for prediction of N requirements at Turkmenistan Experimental site

STEP 1	STEP 2	STEP 3	STEP 4		STEP 5	STEP 6	STEP 7	STEP 8	STEP 9			STEP 10
Enter Plot NDVI	Enter number of days from planting where GDD> 0	Compute INSEY	Compute **YPo**	Determine **Rindvi**	Riyield	Compute **YPn**	YPmax determined by agronomist (YPn cannot exceed YPmax)	Determine Grain N uptake at **YPo**	Determine Grain N uptake at **YPn**		NUE=0,0041 N needed + 0,0831	Detemine fertilizer N requirement
		= NDVI/ Days, GDD>0	**YPo**= 1797,7*exp(232,6*INSEY)	**RI**=NDVI (Nitrogen Rich Strip)/NDVI (farmer check)	**Riyield(=Y) = 0,3381*Rndvi + 1,168**	**YPn**=YPo * RI	**YPn(cap)<= 7000 kg/ha**	GNUP_YPo = YPo in kg/ha * 0.0239	GNUP_YPn = **YPn** in kg/ha * 0.0239%			FNR = (GNUP_YPn - GNUP_YPo)/0.5043
NDVI	**GDD**	**INSEY**	**YPo, kg/ha**	**RI ndvi**	**RI yield**	**YPn, kg/ha**	**YPn(cap), kg/ha**	**GNUP_YPo**	**GNUP_YPn**	**N needed**		**FNR, kgN/ha**
0.38	118	0.00322	3802.1	1.7	1.7	6639.1	6639.1	90.9	158.7	67.8	0.36	192.8
0.42	118	0.00356	4114.0	1.5	1.7	6957.2	6957.2	98.3	166.3	68.0	0.36	193.3
0.4	118	0.00339	3955.0	1.6	1.7	6791.7	6791.7	94.5	162.3	67.8	0.36	192.8
0.45	118	0.00381	4364.7	1.4	1.7	7228.9	7000.0	104.3	167.3	63.0	0.34	179.1
0.46	118	0.0039	4451.6	1.4	1.6	7325.5	7000.0	106.4	167.3	60.9	0.33	173.2
											0.4	186.3

NDVI Rich Strip =	0.65
NUE	35%

vi. Use of sensor for Chickpea varieties

8B. Developing a methodology for screening of improved Chickpea germplasm- for vigor and weed competitiveness.

Evaluating the performance of chickpea cultivars for cold, drought and salinity onditions- Efforts towards Crop Diversification through Evaluation of the Chickpea cultivars (ICARDA-component of developing a methodology) .

The study was conducted in Tashkent Agrarian University experimental site in Uzbekistan with the objective to evaluate yield potential of spring planted chickpea cultivars, multiply seed for further research, and evaluate plant vigour during crop season so that selected cultivars are competitive to weeds and are stable for spring and winter season plantings.

The species were sown in randomized complete block design on 5 March 2008 in a non-saline soil (EC=10-13 ms/m). Seedling emergence was noted in late March / early April 2008 for different cultivars. Green seeker Optical sensor was used to determine NDVI values at 7 day interval from germination to crop maturity stage. Because of breeder seed restrictions, thirty-six (36) cultivars were planted in two replications. The plot size was 2.1 m^2 ($0.7\times3.0=2.1$ m^2). Total number of subplots was $36\times2=72$. Typical plant (NDVI) growth curves /dynamics of the cultivars are shown on Figure 9 for all the chickpea accessions.

NDVI indices show that there were wide variations in early growth vigor of the cultivars. The varieties that are more vigorous in early growth stages compete with weeds more efficiently. Using the NDVI measurements, cultivars were categorized into (i) maturity group – early and late, (ii) crop vigor at early and mid-season growth rates and (iii) the yield potential. Results of the trials are given in Table 4.

Based on the field results five high yield cultivars with yield potential > 3tons/ ha - (2) from the early maturity and (3) from late maturity group were identified. It was observed that cultivars such as FLIP 03-63C with good early and mid season vigour, high yield potential and early maturing can be very useful in the crop diversification program in Central Asia.

The conclusion that cultivar like FLIP 03-63C (high yield potential) is very appropriate. From the regional perspective, it is observed that cold is very common in early growth stages. Thus, lines which are moderately vigorous in early season, will escape cold and fast vigor in mid late season will help them escape terminal drought conditions. Therefore, the germplasm should also be subjected to winter cycle for devising the right strategy for screening of the newly developed germplasm to promote diversification of cotton-wheat systems in Central Asia. The trial need would be repeated in winter 2008 for cold and water stress tolerance.

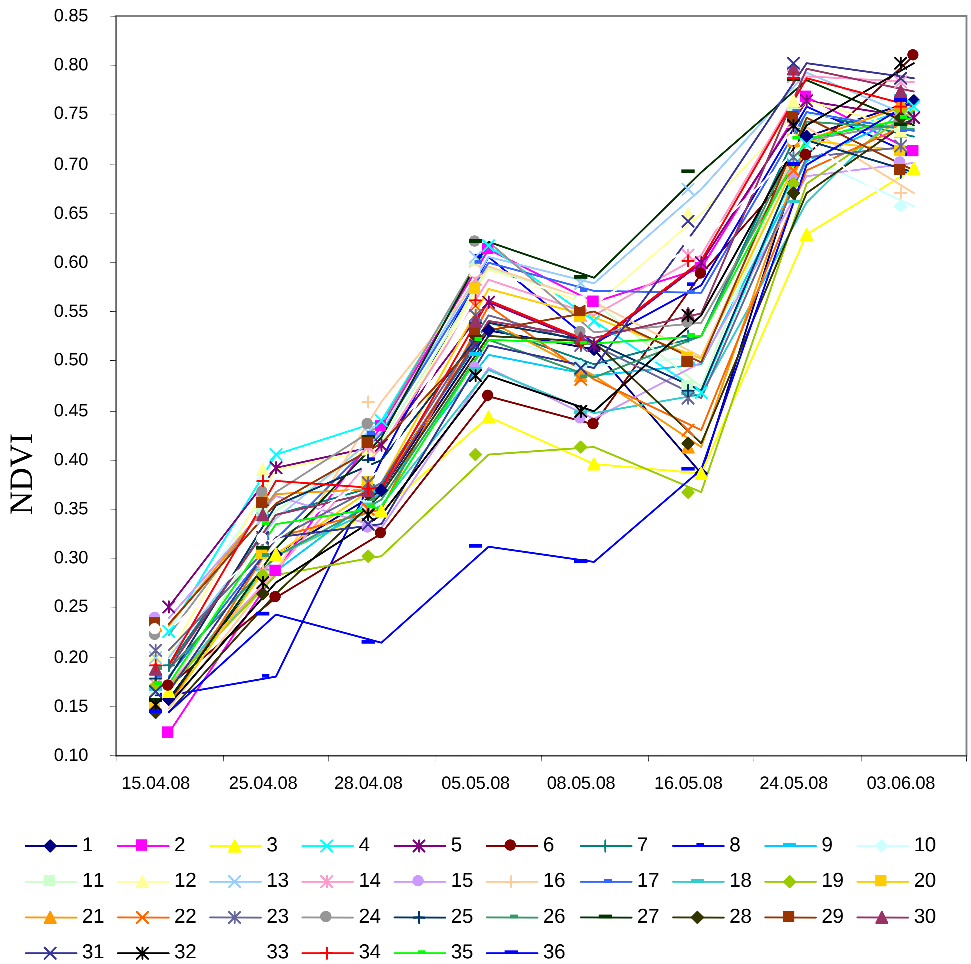

Figure 9 NDVI values of chickpea at TAU site on different dates

Table 4 Crop characterization of 36 chickpea cultivars at Tashkent Agrarian University site

SNo.	Entry name	In-season Vigor		Maturity Group	Crop yield, t/ha
		Early	Mid-late		
1	FLIP 97-118C	M	M	E	1.97
2	FLIP 97-120C	S	M	E	2.07
3	FLIP 99-34C	M	S	E	1.84
4	FLIP 00-20C	M	M	E	2.53
5	FLIP 01-32C	F	M	E	2.36
6	FLIP 01-50C	M	F	L	3.35
7	FLIP 01-52C	M	M	E	2.57
8	FLIP 01-63C	M	F	E	2.92
9	FLIP 02-02C	M	M	E	2.43
10	FLIP 03-17C	M	S	E	1.35
11	FLIP 03-31C	M	F	L	2.69
12	FLIP0 03-35C	M	F	L	2.89
13	FLIP 03-63C	M	F	E	3.30
14	FLIP 03-71C	M	F	E	2.37
15	FLIP 03-74C	M	S	L	2.81
16	FLIP 03-83C	M	S	L	1.66
17	FLIP 03-87C	M	M	E	1.61
18	FLIP 03-132C	S	M	E	1.54
19	FLIP 03-134C	S	F	L	2.55
20	FLIP 03-135C	S	S	E	2.03
21	FLIP 03-150C	S	F	L	2.51
22	FLIP 03-151C	S	M	E	2.52
23	FLIP 03-152C	M	M	E	2.55
24	FLIP 04-2C	F	M	E	2.01
25	FLIP 04-4C	M	F	E	2.59
26	FLIP 04-18C	M	F	L	3.00
27	FLIP 04-31C	S	F	E	3.46
28	FLIP 04-32C	S	M	E	2.33
29	FLIP 04-34C	M	M	E	2.25
30	FLIP 04-35C	M	F	L	3.19
31	FLIP 04-38C	S	F	L	1.46
32	FLIP 82-150C	S	F	L	2.37
33	FLIP 88-85C	S	S	E	2.32
34	FLIP 93-93C	M	F	E	1.97
35	ILC 482	M	M	E	0.78
36	Uzbekistansky 36	S	S	E	2.26

Note = F-Fast, M-Moderate, S-Slow Maturity Group = (E-Early, L- Late)

vii. Use of sensor for prediction of N application at cotton field

The study was conducted under ZEF-UNESCO Project with the objective to evaluate Nitrogen response of cotton cultivars under saline conditions in Urgench University experimental site in Uzbekistan. The data is being collected by technical staff of the ZEF-UNESCO Project.

Future plans for using of Greenseeker

- To develop calculator for N prediction for winter wheat crop at rainfed and irrigated conditions
- To develop calculator for N prediction of winter wheat at different soil moisture conditions (pre-irrigation soil moisture 60, 70, 80 FC)
- To predict N requirements of different crops (winter wheat, safflower, alfalfa and other) and to study the crop growth and find critical stages of crop development crops where N rates could be predicted.
- To compare crop growth and development of different crops under traditional and minimum tillage technology at different cropping system.
- To identify higher yielding varieties of chickpea under irrigated and rainfed conditions.
- Plant breeding, variety selection purposes under zero-till and traditional tillage technologies.
- To predict N requirements of winter wheat for wheat-cotton intercropping system when winter wheat is planted in standing cotton without tillage and after cotton harvesting followed by traditional tillage.
- To stabilize the soil structure and elaborate calculator for prediction of N requirement.
- To study effect of erosion on crop yield under slopping conditions/ erosion risk
- To study effect of shallow groundwater level on crop yield in lowlands and predict of N rates at these conditions.

Field visit to ZEF experimental sites in Uzbek Cotton Growing Institute experimental site in Khorezm province on 10th August 2008

Field day was organized with the purpose to widely demonstrate the Conservation Agriculture technologies implementation and NDVI measurements using Greenseeker among national scientists from CAC countries in Uzbek Cotton Growing Institute (UCGRI) experimental site near to Urgench city.
Field day was organized by scientists of ZEF on 10th August 2008. ZEF staffs (Ms. Mina Devkota and Mr. Krishna Devkota) have exchanged their experiences related to Conservation tillage technology among all invited scientists and visitors.
Around 20 participants attended the Field Day.
Participants visited 2 fields belong to UCGRI site.

1. **Effect of conservation tillage, residue management and Nitrogen application technology on cotton yield**.

   Objective: Cutting of cost production of cotton and wheat by using conservation tillage technologies in down streams of Amudarya river basin in Khorezm province of Republic Uzbekistan

The experimental site is located in Amudarya zone of Khorezm province. Geographical coordinates: 41^{o} N, 61 ^{o} E. Altitude is 94 a.m.s.l. The average amount of precipitations is 100 mm/year with maximum observed in spring season. Maximum air temperature was observed (43^{o}C) in July and minimum -15 ^{o}C in December. Evapotranspiration is 1500 mm.
The soil is alluvial-meadow and soil texture can be characterized by finer soil texture (silt loam) in upper soil depth and by course soil texture (sandy soil) in down horizons. Organic matter

content is 1-1.2%. Salinity is high (>1200 mg/L). There are higher amount of calcium and hydro carbonates in the soil profile. Limitation factors: draught, irrigation water scarcity, soil salinity, higher water table, low soil fertility level.

Treatments:

1. Planting system -2: raised bed and conventional farmer practiced
2. Residues level-2: with and without residues
3. N application rates-3: 0N, 125N, 250N.

Total number of treatments -2×2×3=12. Replications -4. Total number of subplots -48. Subplots area = 11×50=550 m^2.

Fertilizers were applied in 2 splits: 50% in 2-4 leaves stage and 100% in flowering stage.

Expected results:

- Achieving higher yields under using conservation agriculture technologies (residues, permanent beds, sowing in 2 rows in beds).
- Synchronizing of crop yields
- Soil fertility enhancement
- Soil salinity decreasing
- Recommendation to farmers and dissemination of results

Participants get knowledge how Experimental layout should be established in the field and Dr. Bram suggested following recommendation:

- measurement should be done in center of the experiment,
- it is desirable to have minimum 8 beds to be in each subplots,
- minimum 2 furrows should be permanent where NDVI to be measured,
- nobody should take destructive plant or soil samples in the yield determination strip ,
- protection border zone (0.5 m) should be established between subplots,
- Take NDVI measurements between furrows.

In addition Ms Mina showed experimental trials where they used 35N Urea by spray starting from 2-4 leaves stage every week. The condition of plants was much better in comparison with application of fertilizers to the soil.

Participants were able to see the visible positive impact of conservation technology to enhancement of crop yield in the field.

2. Effect of water saving technology, conservation tillage and residue management technology on rice yield.

Objective: Cutting of cost production of rice by using conservation tillage technologies in down streams of Amudarya river basin in Khorezm province of Republic Uzbekistan

The experimental site is located in Amudarya zone of Khorezm province. Geographical coordinates: 41° N, 61 ° E. Altitude is 94 a.m.s.l. The average amount of precipitations is 100 mm/year with maximum observed in spring season. Maximum air temperature was observed (43°C) in July and minimum -15 °C in December. Evapotranspiration is 1500 mm.

The soil is alluvial-meadow and soil texture can be characterized by finer soil texture (silt loam) in upper soil depth and by course soil texture (sandy soil) in down horizons. Organic matter content is 1-1.2%. Salinity is high (>1200 mg/L). There are higher amount of calcium and hydro carbonates in the soil profile. Limitation factors: draught, irrigation water scarcity, soil salinity, higher water table, low soil fertility level.

Treatments:

1. Irrigation system -2: Traditional-flooding (irrigation with constant level of water) and irrigation by regulation of water depth and irrigation in intermediate season
2. Tillage system-3: Traditional (CT), Raised bed, Zero Tillage
3. Residues level-3: 25%, 50%, 100%

Expected results:

- Achieving higher yields under using conservation agriculture technologies (residues, permanent beds, advanced irrigation).
- Economy of irrigation water
- Soil fertility enhancement
- Soil salinity decreasing
- Recommendation to farmers and dissemination of results

Participants get knowledge how Experimental layout should be established in the field and Dr. Bram suggested following recommendation:

- NDVI measurement should be done in order to study crop growth of different rice cultivars

Participants were able to see the visible positive impact of conservation technology to enhancement of rice crop yield in the field. It was visible that rice crop yield will not damaged even when water did not cover overall all rice check basin. Significant amount water could be saved under using irrigation water in intermediate season.