The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2242-19

Joint ICTP-IAEA Workshop on Uncovering Sustainable Development CLEWS; Modelling Climate, Land-use, Energy and Water (CLEW) Interactions

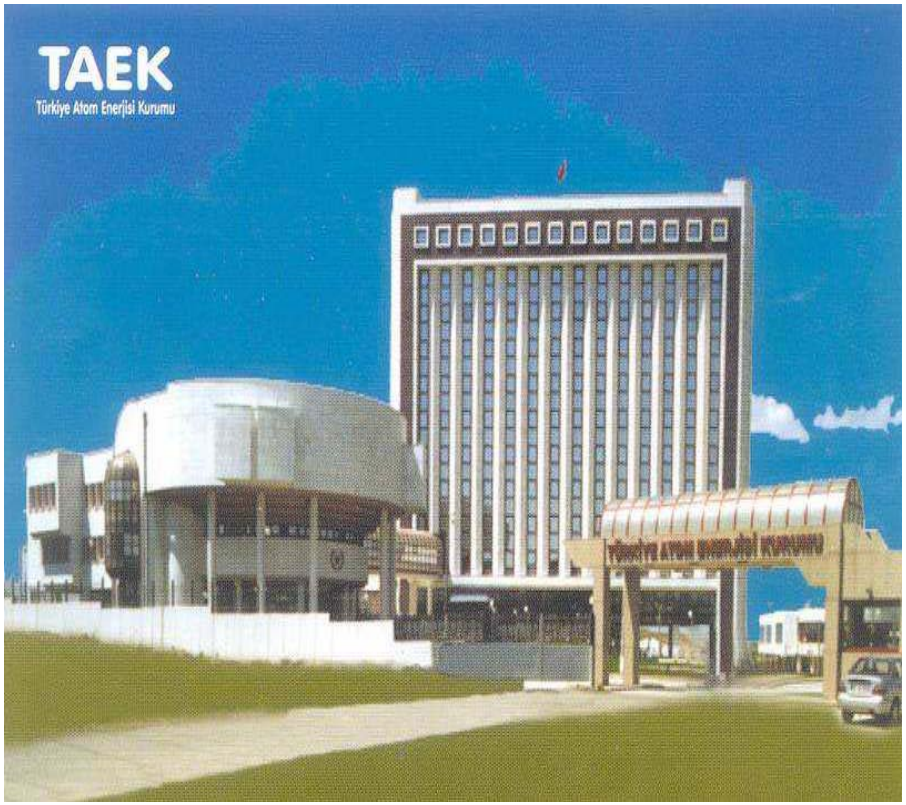
30 May - 3 June, 2011

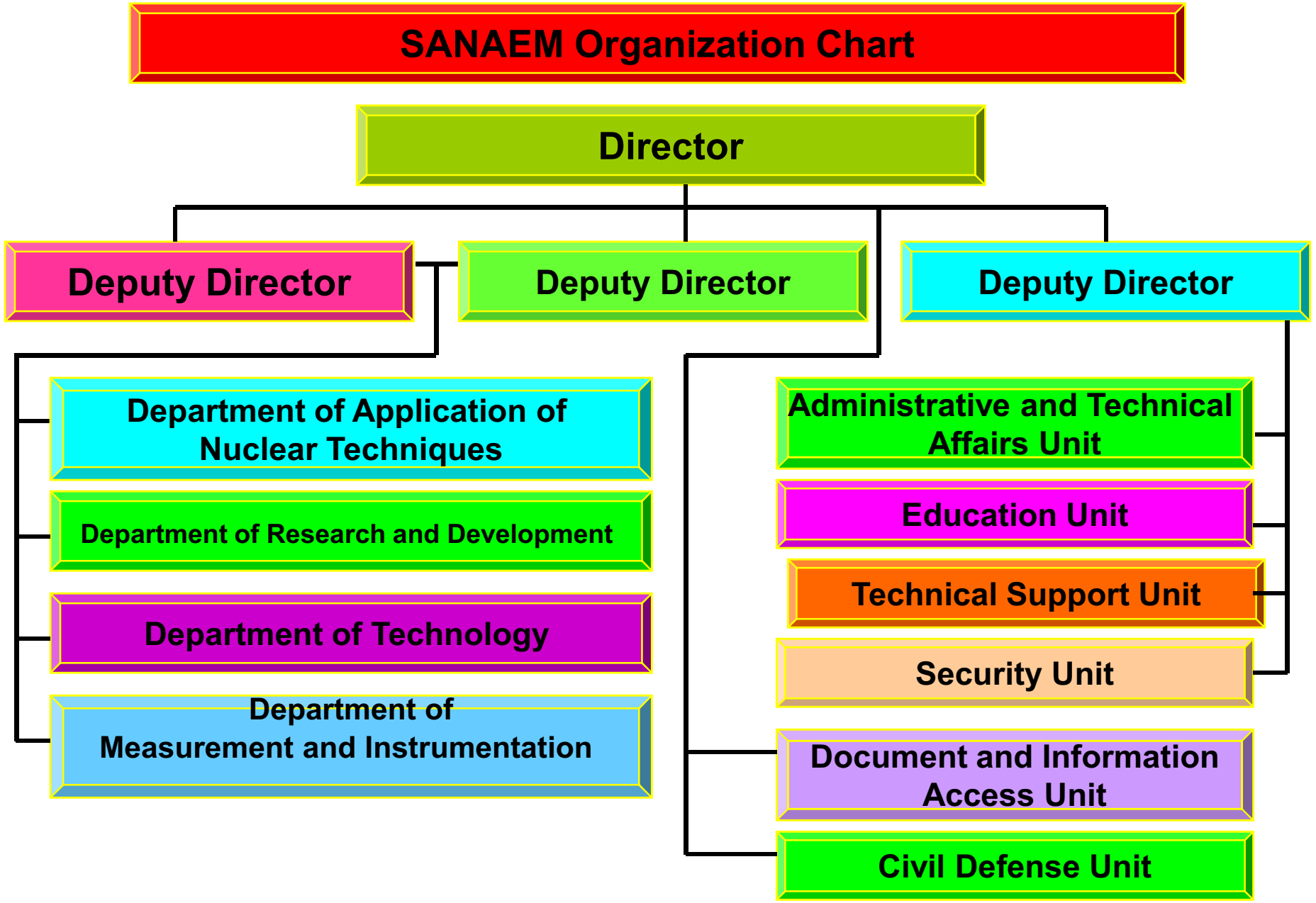
A case study - Turkey

HALITLIGIL Mahmut Basri
Ankara Nuclear Agariculture and Animal Research Center
Istanbul Yolu 30-Cu-Km
Saray
Ankara
TURKEY

TURKISH ATOMIC ENERGY AUTHORTY (TAEA)

SARAYKÖY NUCLEAR RESEARCH and TRAINING CENTER (SNRTC)




SANAEM Organization Chart
Director
Deputy Director
Deputy Director
Deputy Director
Department of Application of Nuclear Techniques
Department of Research and Development
Department of Technology
Department of Measurement and Instrumentation
Administrative and Technical Affairs Unit
Education Unit
Technical Support Unit
Security Unit
Document and Information Access Unit
Civil Defense Unit

A) Department of Application of Nuclear Techniques

The activities are carried out at the following units:

1. **Nuclear Agriculture**
2. **Health Physics**
3. **Gamma Irradiation Facility**
4. **Food Science**
5. **Human Heath**
6. **Animal Science**

B. Department of Research and Development

The activities are carried out at the following units:

- Fusion Unit
- Polymer Chemistry Unit
- Accelerator Physics Unit
- Fission Unit
- Radiation Detection Systems Unit

C. Department of Measurement and Instrumentation

- Radioactivity Measurement and Analysis Unit

- Analytical Measurement and Analysis Unit

- Nuclear Electronics and Instrumentation Unit

D. Department of Technology

The activities are carried out at the following units:

- Material Characterization Unit
- Dosimetry Unit
- Accelerator Technologies Unit

CASE STUDY

"SUCCESS STORY OF DRIP IRRIGATION AND FERTIGATION IN TURKEY THROUGH FAO/IAEA TECHNICAL COOPERATION PROJECTS"

Associated Prof. Dr. MAHMUT BASRİ HALİTLİGİL

HEAD,
DEPARTMENT OF APPLİCATİONS
SARAYKÖY NUCLEAR RESEARCH AND TRAİNİNG CENTER (SNRTC)
TURKİSH ATOMİC ENERGY AUTHORİTY (TAEA)

This presentation will cover mainly two aspects

a) first one is about the three FAO/IAEA-funded TC pojects in Turkey for improving water and nitrogen management in the Cappadocia region (Niğde-Nevsehir Region-where nearly 1.2 million tons of potato production is obtained yearly which is 1/3 of Turkey's whole production)

b) the second is the IAEA - CRP funded project about soil conservation under different soil management systems including various rotation systems in Ankara Region.

FIRST ASPECT

IN NİĞDE-NEVSEHİR REGİON-WHERE CULTIVATED AREA İS ABOUT

30 000 HECTARES, THERE ARE NEARLY 2000 FARMERS

THE SOİLS ARE MAİNLY

LİGHT-TEXTURED,
COMPOSED OF

SANDY,

LOAMY SAND
and/or SİLT LOAM.

IN THE REGİON LAND USE AND FARMİNG PRACTİCES İNFLUENCE THE EFFİCİENT USAGE OF WATER FOR AGRİCULTURAL PRODUCTİON.

EXCESSİVE USE OF WATER CAUSES TO THE LOSSES OF NOT ONLY WATER BUT ALSO NUTRİENTS AND AGROCHEMİCALS FROM FARMLANDS, IN ADDITION TO HUMAN AND ANIMAL HEALTH PROBLEMS (Nitrate –N concentrations are over 100 ppm). **Unfortunately GROUND WATERS ARE THE ONLY SOURCE IN THE REGION for ALL uses.**

STATE WATER AFFAİRS OF TURKEY HAD OFFİCİALLY HAVE BEEN WARNİNG THAT THE WATER LEVELS OF THE DEEP WELLS İN THE REGİON WAS DECREASİNG

2 to 3 METERS YEARLY İN THEİR ANNUAL REPORT OF 1997.

PRİOR TO OUR STUDİES BEİNG CONDUCTED, SPRİNKLER İRRİGATİON SYSTEMS WERE BEING USED FOR POTATO GROWİNG SİNCE 1960'S AND BEFORE THE SPRİNKLER İRRİGATİON THE BASİN İRRİGATİON SYSTEM WAS POPULAR.

TUR/5/016 'USE OF NUCLEAR TECHNİQUES İN SOİL FERTİLİTY AND PLANT NUTRİTİON' DURİNG (1990-1993)

(Doç. Dr. Mahmut Basri Halitligil - main counterpart)

Farmers in the region was applying nearly 5 tons of Ammonium sulphate fertilizer per hecare for potato which was 1000 kg N/ha and they were applying more than 1300 mm water during the growth period. We had used ^{15}N labelled fertilizer for potato N rate experiments to find out the fate of applied N fertilizer for the first time in this region.

İNSTİTUTES THAT WERE INVOLVED WERE:

Turkish Atomic Energy Authority, Ankara Nuclear Research Center in Agriculture

Ministry of Village and Rural Affairs, Lodumlu Research and Training Center

Our 3 location - 3 year experiments in the region have shown that 35 565 kg/ha optimum marketable potato tuber yield by applying minimum 1400 mm water with sprinkler irrigation, was obtained by applying only 600 kg N/ha not 1000 kg N/ha ammonium sulphate

These experiments showed that the amount of N fertilizer in the 0-200 cm soil layer increased nearly 3 times when the N rate was increased from 600 to 1000 kg N/ha; and two times more N fertilizer was leached beyond 200-cm soil depth when 1000 kg N/ha was applied in stead of 400 kg N/ha rate which implied to us that the nitrogen leaching may be causing nitrate contamination of ground waters in the region.

	Nitrogen Fertilizer Rate		
	400 kg N/ha	600 kg N/ha	1000 kg N/ha
Total fresh tuber yield (kg/ha)	34 365	35 565	33 287
Nitrogen taken up by potato from the fertilizer kg N/ha	114	134	131
% NUE	28.5	22.3	15.3
Fertilizer N residue in 0 - 200 cm soil layer (kg N/ha)	182	207	608
Fertilizer N lost leaching below 200 cm of soil (kg N/ha)	104	259	261

OUTCOMES FROM THIS EARLY N-15 RESEARCH WORKS:

All these research results clearly showed that farmers in the region were applying excessive nitrogen fertilizer and water to the potato . This trend of crop production in the region was causing very low nitrogen and water use efficiencies of potato. Also due to the high intensity of water leaching, it was assumed that the wells could be contaminated with nitrate.

About 1400-1700 mm of water was required under sprinkler irrigation to achieve marketable potatoes, of which only 35% is taken up by the crop roots in the top 90 cm of the soil.

The remaining 65% was lost through runoff and downward movement of water beyond the plant roots. This excessive use of water also reduces the efficiency of water-soluble nitrogen (N) fertilisers, such as urea or ammonium sulphate, in providing nitrogen for potato production.

The main challenges were to increase the water and N fertiliser use efficiency by applying irrigation water mixed with fertilisers to the right place, at the right time and in the appropriate amount.

THESE RESEARCH OUTCOMES LET US TO THINK OF TAKING SOME MEASURES IN THE REGION TO OVERCOME THE PROBLEMS

Therefore, some **different irrigation** and **N fertilization practices** were necessary in the region. It was thought that **drip irrigation** and **fertigation**, where nitrogen and water will be applied in limited amounts, can be a remedy fore overcoming the water shortages in near future and especially for lessening the nitrate contamination of ground waters in this region.

So, the investigations were started with TUR/5/020 Project

IAEA-TC PROJECT TUR/5/020

(During 1998-2002)

DRIP IRRIGATION AND FERTIGATION OF POTATO UNDER LIGHT-TEXTURED SOILS OF CAPPADOCIA REGION – TURKEY

Main Counterpart: Doç. Dr. Mahmut Basri Halitligil

İNSTİTUTES THAT WERE INVOLVED WERE:

Turkish Atomic Energy Authority, Ankara Nuclear Research Center in Agriculture and

Ministry of Agriculture, General Directorate of Research, Potato Research Institute, Nigde-Turkey

Ankara University, Agricultural Faculty, Soil Science Department, Ankara - Turkey

Experiments were done at 2 farmers field (which included 10 hectare demonstration experiments in addition to the small scale core experiment. Only in core experiments we had used nuclear techniques) at different locations and one at Nigde Potato research Institute for 3 years

FOR THIS PUROSE THE FİELD EXPERİMENTS WERE ESTABLISHED AT 3 LOCATİON IN THE REGION (TWO OF THEM AT FARMERS FIELD AND ONE AT NPI FOR 3 YEARS

WITH TREATMENTS

300 kg N/ha Drip Irrigation + Fertigation

600 kg N/ha Drip Irrigation + Fertigation

900 kg N/ha Drip Irrigation + Fertigation

600 kg N/ha Soil Application + Drip Irri.


TRT


TRT


HANAKON
N_0


TRT

RESULTS OBTAINED FROM THESE DRIP IRRIGATION+FERTIGATION EXPERIMENTS

A) The results obtained showed that 36 241 kg/ha mean total marketable potato tuber yield was obtained with application of 600 mm irrigation water (At each experiment 12 irrigations were done during the whole growing season and 50 mm of water was applied at each irrigation, so totally 600 mm of water was applied at each experiment).

Drip fertigation technology leads to a reduction both in soil water evaporation and in excess water draining away below the roots, so that much less irrigation water as well as N fertiliser are needed.

B) Tuber yields and % NUE increased when N was applied with drip irrigation-fertigation system in comparison to the application to the soil and then drip irrigation.

C) At harvest, more N was accumulated at 0-30 and 30-60 cm depths with fertigation treatments.

	Nitrogen Fertilizer Rate	
	600 kg N/ha Dripp Irrigation + Fertigation	600 kg N/ha Soil Application + Dripp Irrigation
Total fresh tuber yield (kg/ha)	36 241	35 450
Nitrogen taken up by potato from the fertilizer kg N/ha	286	229
% NUE	47.7	38.2
Fertilizer N residue in 0 - 90 cm soil layer (kg N/ha)	170	176
Fertilizer N lost as denitrification or volatilisation (kg N/ha)	144	195

It was also found that water did not move below 90 cm of soil layer in drip irrigation-fertigation system, suggesting that no N movement occurred beyond 90 cm soil depth. Although the % ^{15}N a.e. values of the soil solutions taken from the tensionics were highest in those placed at the 65 cm soil depth, no ^{15}N was detected at the 85 cm depth for all locations and for every treatment.

	28.10.2000 Suvermez		27.10.2000 Hasakoy		26.10.2000 Institute	
	65 cm depth	85 cm depth	65 cm depth	85 cm depth	85 cm depth	85 cm depth
	%^{15}N a.e.					
No ^{15}N Fertilizer (N0)	0	0	0	0	0	0
300 kgN/ha Drip İrrigation + Fertigation (N1)	0,019	0	0,009	0	0,012	0
600 kg N/ha Drip Irrigation + Fertigation (N2)	0,095	0	0,036	0	0,025	0
900 kg N/ha Drip Irrigation Fertigation (N3)	0,055	0	0,076	0	0,089	0
600 kg N/ha Soil application of N and drip Irrigation (Ns)	1.060	0	1.273	0	1.43	0

THE ROLE OF NUCLEAR AND RELATED TECHNIQUES IN THESE EXPERIMENTS

A) Soil water measurements in these experiments were obtained by using neutron probe.

Nearly 65 % of savings in the use of irrigation water was obtained because by using the drip irrigation + fertigation system only 600 mm of irrigation water was used to obtain 36 241 kg marketable tuber yield, however, by the sprinkler irrigation system minimum 1400 mm of irrigation water was used to obtain 35 565 kg marketable tuber yield.

THİS RESULTED İN:

- MORE THAN TWO TİMES LESS WATER PUMPİNG UP FROM THE WELLS

- SAVİNGS İN TİME, ELECTRİCİTY AND LABOUR WAS OBTAİNED

- NO NİTROGEN WAS FOUND İN THE SOİL SOLUTİONS OLLECTED BY TENSİONCS AT 85 CM DEPTH

B) With using ^{15}N labelled ammonium sulphate fertilizer

It was proven that (with conventional research techniques it could not be possible):

- Nitrogen was consumed by potato more efficiently by the drip irrigation + fertigation system where nearly 48 % Nitrogen Use Efficiency was obtained in comparison to the sprinkler irrigation system where 22 % Nitrogen Use Efficiency was obtained.

- Fertigation of nitrogen, the application of fertilizer in irrigation water did yield better in comparison to the application of nitrogen fertilizer to the soil surface and mixing and then irrigating with the drip irrigation system

C) Soil solutions at different depths were taken by Tensionics

Using tensionics enabled us to collect soil solutions from different depths of soil without any digging of soil and getting soil solution from it. These soil solutions were analyzed for total and ^{15}N labeled nitrogen with Optical Emission Spectrometer, NOI7, in our IAEA Certified ^{15}N laboratory in Ankara.

SUCCESS OF THE PROJECTS

- The improvement of this project was explained to the Turkish Parliamenters (at the Finance Evaluations of the Government) every year by TAEA and by Ministry of Agriculture

On July 27, 2000 a 12 minute PUBLICITY WAS DONE USING THE NATIONAL TV (TURKISH RADIO TELEVISION–TRT) by an interview on site at Nigde in the farmers field to show why the dirip irrigation+fertigation system should be used in the region.

The interviewer asked questions and got answers from Doç. Dr. Mahmut Basri Halitligil, Hüseyin Onaran and the farmer Erim Mengü. They pointed out that yearly 60 million dollar savings would be attained in the region if all farmers used drip irrigation+fertigation system instead of conventional sprinkler system. They also mentioned that leaching of nitrate, thus the contamination of waters, in the region will be avoided.

They emphasized that the establishment of the drip irrigation+fertigation system required nearly 200 US$ per hectare, and the farmers can not afford this expense so the government should financially support them.

In April 2003 a BRIEF NOTE FOR THE MINISTER OF AGRICULTURE was prepared by the researchers worked in this project and in August 2004 it was given to Prof. Dr. Sami Güçlü, the Minister of Agriculture.

On 14 November 2004 he had mentioned this situation to the General Assembly of the Turkish Parliment in his speech indicating that drip irrigation and fertigation system will save more than 50 % in water and nitrogen usage in the Cappadocia Region.

So, he emphasized that their government will support the farmers who want to change their system from sprinkler irrigation to the drip irrigation+fertigation.

He also proposed an act indicating the farmers in the region will be supported if they want to establish drip irrigation in their fields by getting very low interest loans. This act was accepted by the General Assembly.

SITUATION IN THE REGION UNTIL 2006

- There were nearly 500 hectare of potato under drip irrigation+fertigation system in the year 2003 and 1000 hectare in 2004 at the Capadocia Region; however, after the governmental support for low interest loans to the farmers in the region, in the year 2006 the area increased to 4000 hectares.

To the farmer, a transition from sprinkler irrigation to drip fertigation has been calculated to require an initial one-off investment cost of up to US $200/ha, depending on the sophistication of the drip fertigation system.

Balancing this investment are projected savings in time,

energy,

fertiliser

water

and

labour costs amounting to an estimated US $2,000/ha/year

As a consequence, interest in drip irrigation + fertigation has been remarkable among potato farmers in the region, so that the area under drip fertigation has increased from 500 to 4000 hectares in only three years (2005-2007) and nearly to 7000 hectares (from 2005 to 2010) in six years totally.

In efforts to further accelerate this transition, the government with the request from Ministry of Agriculture, has developed a regional policy through which it now subsidised 50% of the investment costs for drip irrigation systems.

In 2011 the potato-growing area under drip fertigation is expected to climb to 10000 hectares by the planting time in June due to the easier and special local financial subsidies promised by the governers of Niğde and Nevsehir provinces of the Capadocia Region for this year in addition to the already acting governmental subsidy policy.

IAEA –TC Project TUR/5/024 "Improving Crop Productivity through Nuclear and Related Techniques"

Doç. Dr. Mahmut Basri Halitligil – Main counterpart

(2005-2009 with IAEA support, 2010 –continuing with national support and funds)

This project had the objectives of to improve crop productivity in the light-textured soils of Nigde-Nevsehir Region of Turkey by improving the structure of the soil and fertilizer application and irrigation scheduling to minimize water wastage, land degradation and losses of nutrients and sediments to receiving water bodies that could pose potential threat to the sustainable agriculture.

Alfalfa (for 2 years) - Potato-Alfalfa Rotation		Vetch-Potato-Wheat-Vetch- Potato Rotation	
N_0 Treatment (N fertilizer was not applied)	**N_1 Treatment** (% 10.0 ^{15}N a.e. Ammonium Sulphate fertilizer applied to each crop was) **20 kg N/ha → Alfalfa** **250 kg N/ha → Potato** **^{15}N enriched fertilizer→PILOT**	**N_0 Treatment** (N fertilizer was not applied)	**N_1 Treatment** (% 10.0 ^{15}N a.e. Ammonium Sulphate fertilizer applied to each crop was) **10 kg N/ha → Vetch** **250 kg N/ha → Potato** **150 kg N/ha → Wheat** **Unlabelled N fertilizer→DEMO**

LAYOUT OF 'PILOT' FIELD EXPERIMENT

(which will include ^{15}N, Enviroscan, neutron probe and tensionics)

Vetch-Potato-Wheat-Vetch-Potato Rotation

Alfalfa-Alfalfa-Potato-Alfalfa Rotation

---------- 15. 2 m ----------
---------- 5. 6 m ----------
--- 2. 8 m ------

I N_0 2. 0 m I	N_1		N_0	N_1
N_0	N_1		N_0	N_1
N_0	N_1		N_0	N_1
N_0	N_1		N_0	N_1

LAYOUT OF THE 'DEMOSTRATION' FIELD EXPERIMENT

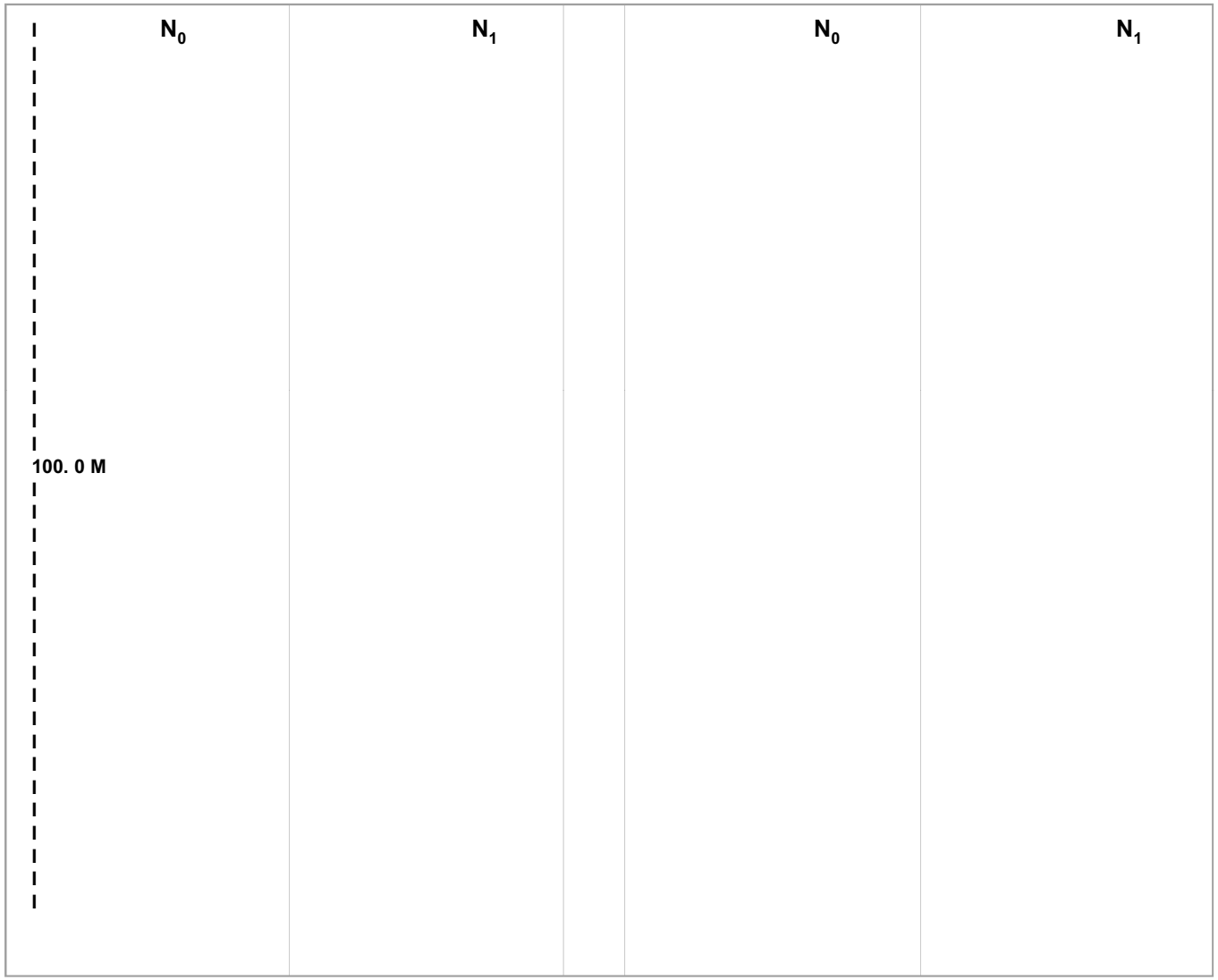
Vetch-Potato-Wheat-Vetch-Potato Rotation

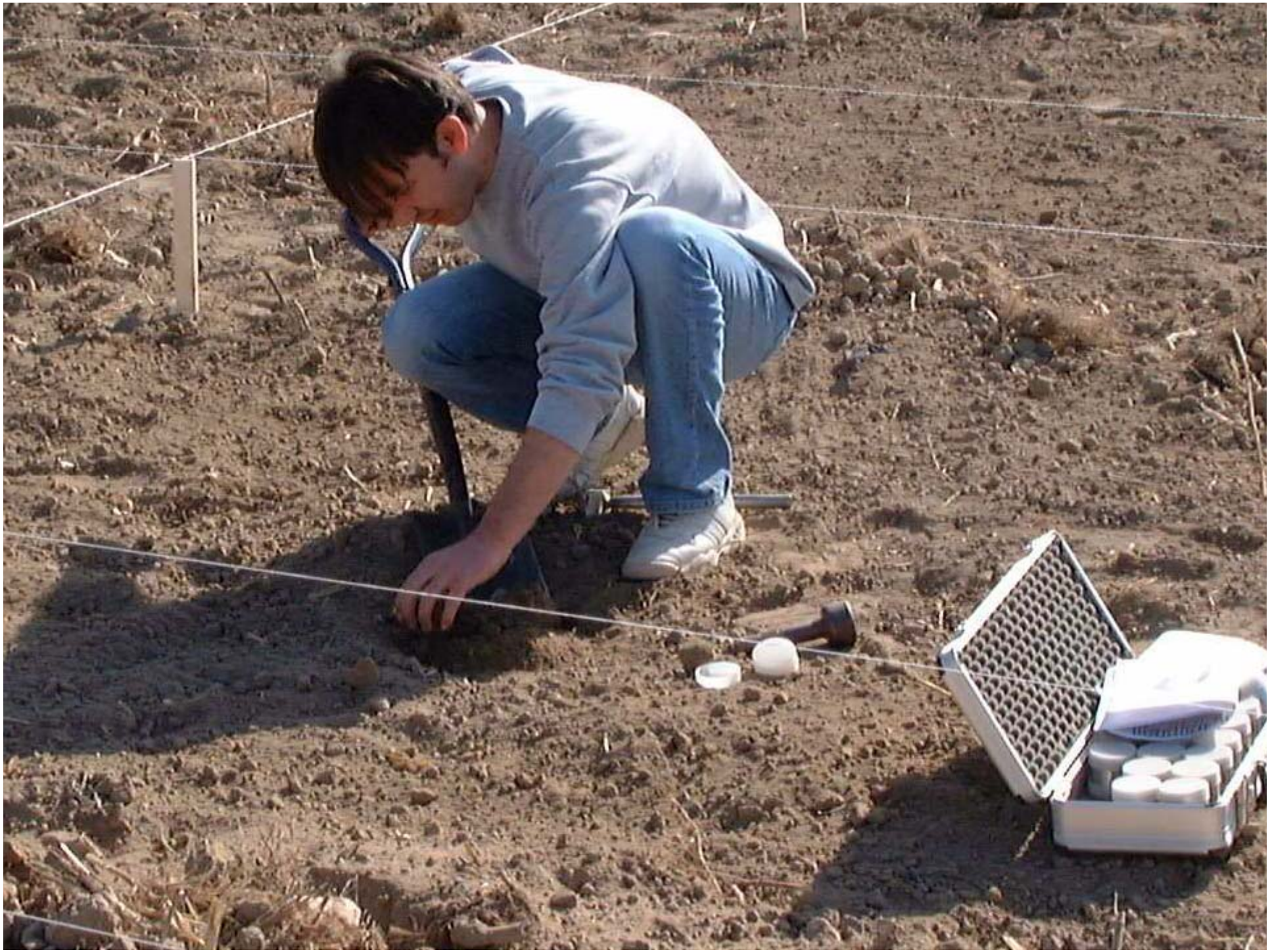
Alfalfa-Alfalfa-Potato-Alfalfa Rotation

---------- 104.0 m ----------

----------50.0 m ----------

---------- 25. 0 m ----------






N1


ATES


2008.07.16 10:01


N1
2008.07.16 10:01

The above results obtained from the Cappadocia Region can be extrapolated to the light textured soils of Central Anatolia - Bolu Region (mainly at the Northern Part of Ankara - around 3 000 hectares) and Agean Sea Region (nearly 5 000 hectare) under nearly similar climatic conditions.

SECOND ASPECT

SOIL ORGANIC MATTER CONTENT UNDER DIFFERENT TILLAGE, NITROGEN AND WATER TREATMENTS IN DIFFERENT CROP ROTATION SYSTEM UNDER ANKARA CONDITIONS

INTRODUCTION

- In general, soils have low organic matter (≤ 1.0 %) and poor structure

- Prevailing farming system is the fallow-wheat rotation in which no residue is incorporated into the soil and deep tillage with moldboard plow is the common cultivation and no irrigation is done

- Earlier research works in the region had shown that these soils can be improved through the legume incorporation into the soil as green manure which may contribute organic matter increase in the soil
- Also, Irrigation and N fertilization can restore organic matter and are necessary for maintaining the crop productivity in this region.

Treatments that were used in the experiment were as:

Rotation : w-w ("wheat-wheat"), v-w ("Hungarian vetch-wheat) , m-w("maize-wheat)

Crop : Wheat (Gerek-79, Akça, Akça, Ukranien and Ukranien varieties were planted in 2004, 2005, 2006, 2007 and 2008, respectively)
: Vetch (Hungarian Vetch in 2004, 2006)
: Maize (Pioneer) in 2008 and 2009

Tillage (T) : I0 (Reduced Tillage with sweep+harrow),
: I1 (Conventional tillage with moldboard plow+harrow)

Irrigation (I) : I0 (No Irrigation),
: I1 (Drip Irrigation + Fertigation)

N Rate (N) : N1 (10, 40 and 100 kg N/ha for vetch, wheat and maize, respectively)
: N2 (20, 80 and 200 kg N/ha for vetch, wheat and maize, respectively)

- **Hungarian Vetch was cut and ploughed 25 cm into the soil when 10 % flowering was obtained. N_2 fixation of vetch plant at 10 % flowering was calculated according to the A – Value method by using the following equation**

$$\frac{(n) \times \%\ \text{Ndff wheat}}{\%\ \text{Ndfswheat}} = \frac{\%\ \text{Ndffvetch}}{\%\ \text{Ndfsvetch}}$$

where

n = N fertilizer rate for vetch / N fertilizer rate for wheat


2008.06.27 08:59


2009.07.24 08:48


2009.07.24 08:45


2009.07.24 08:46

Percent soil organic C

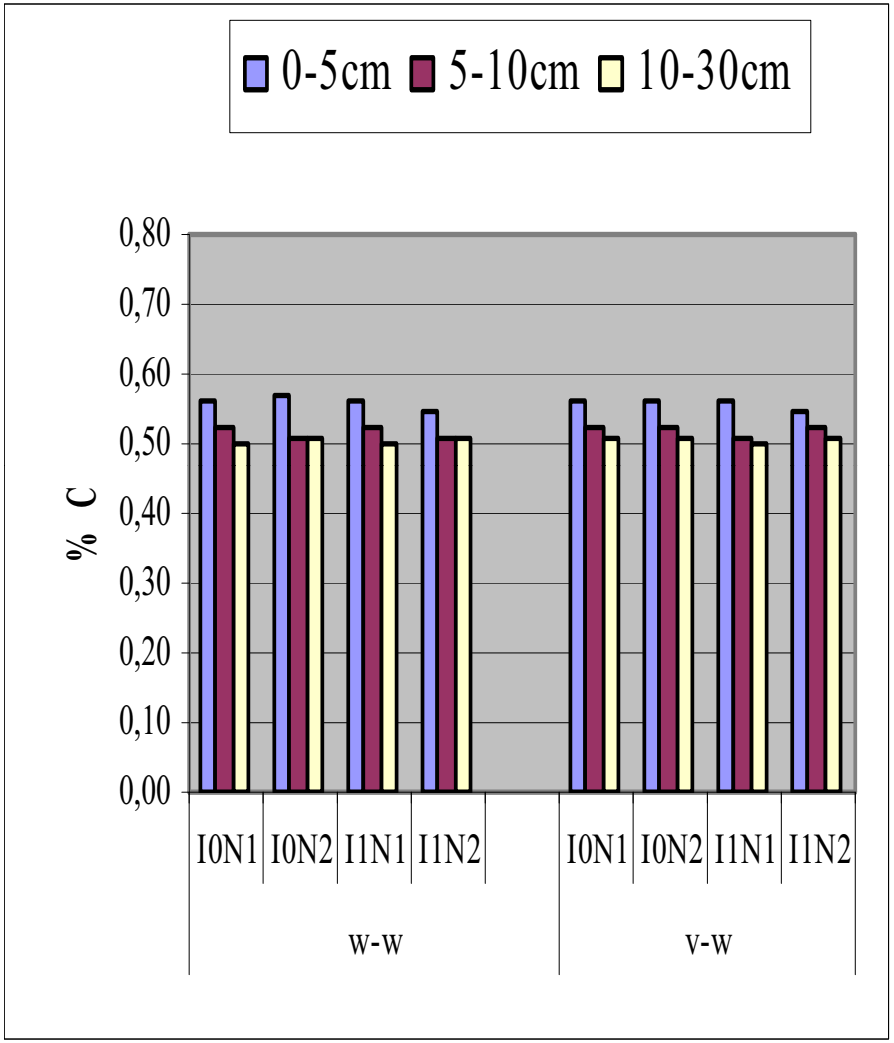


Fig. 8. Percent C values obtained for different treatments in 2004

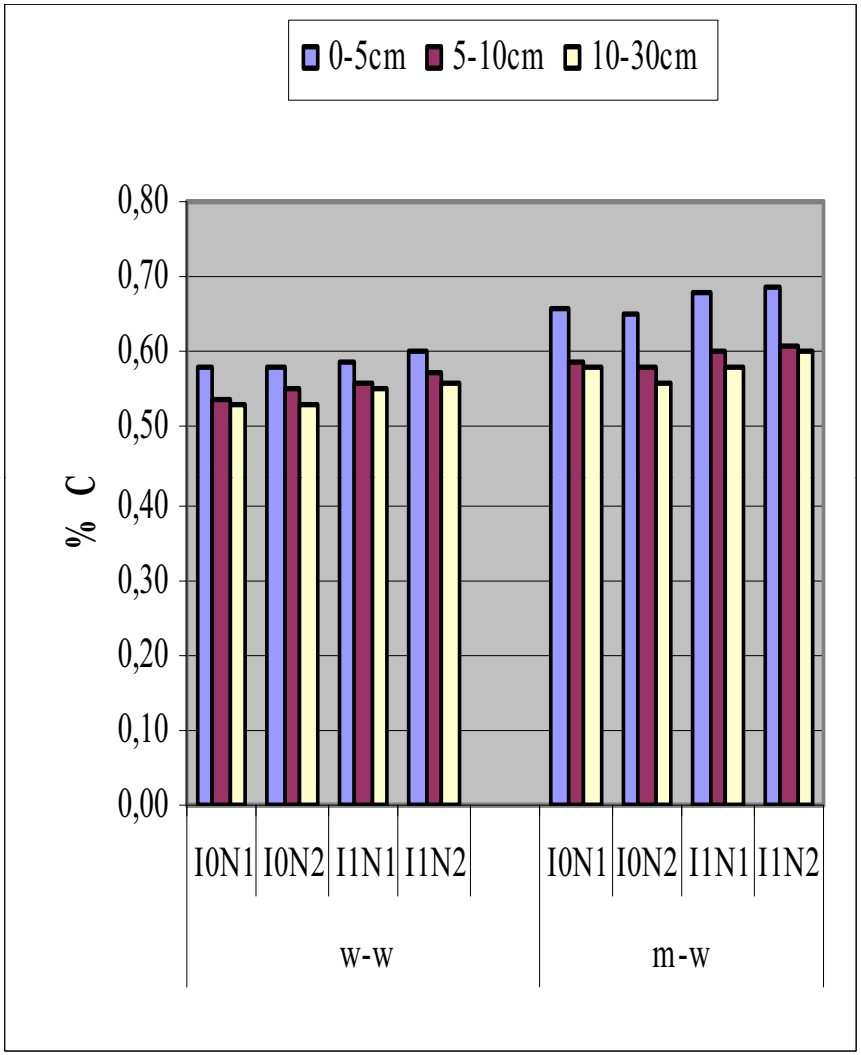


Fig. 9. Percent C values obtained for different treatments in 2009

Soil organic matter

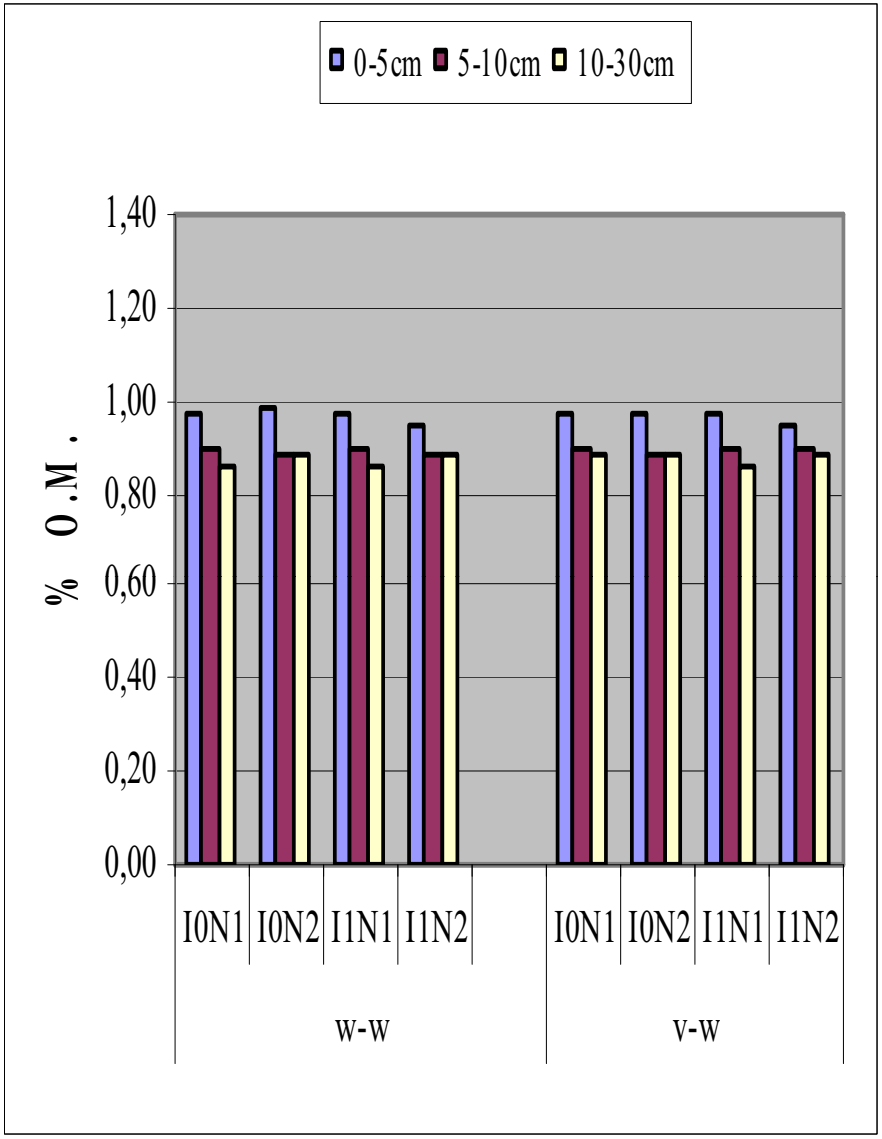


Fig. 10. Percent O.M. values obtained for different treatments in 2004

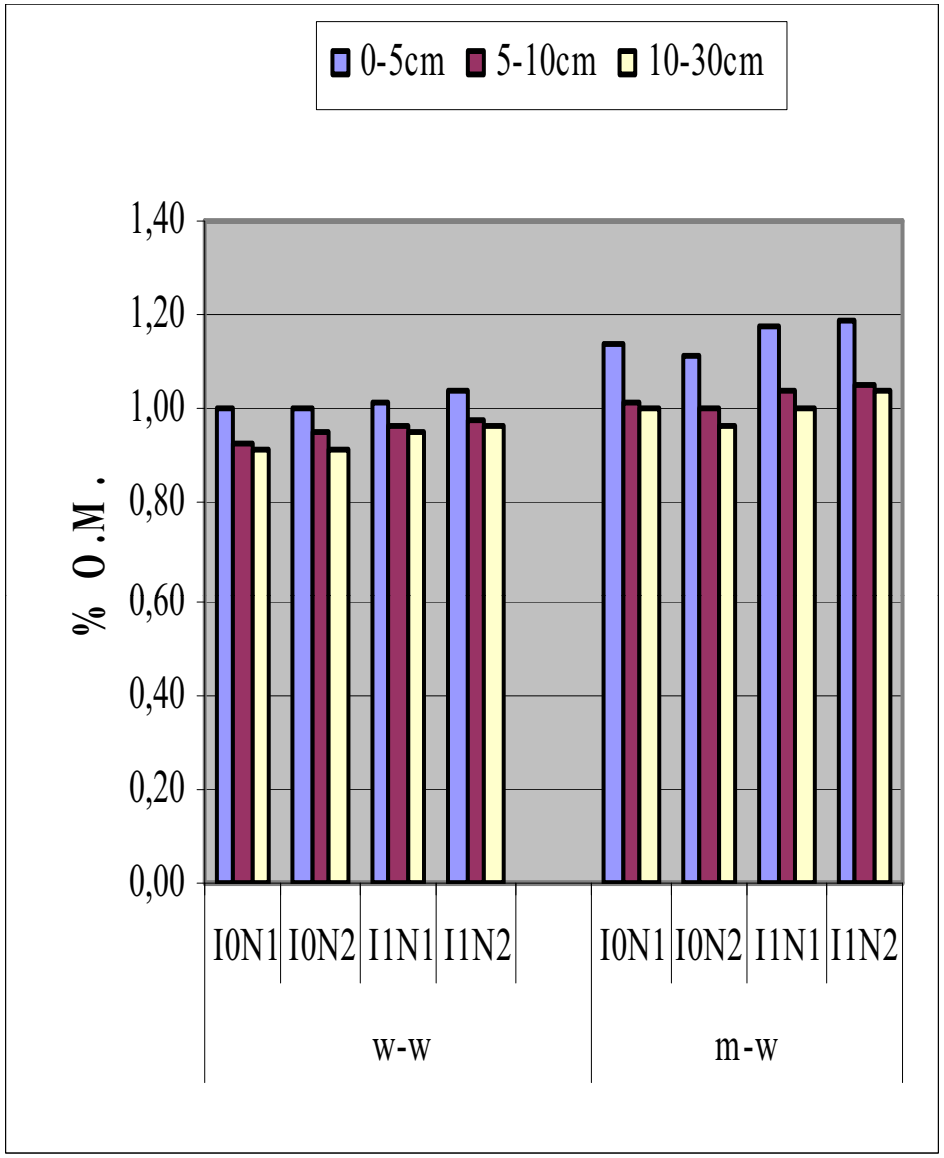


Fig. 11. Percent O.M. values obtained for different treatments in 2009

CONCLUSIONS

A) Nitrogen use of subsequent wheat crop improved significantly in vetch-wheat rotation compared to wheat-wheat rotation especially under the supplementary irrigation. Wheat yields after green manuring of vetch were also, significantly higher then the yields obtained from wheat-wheat rotation.

B) Increases of % C and % OM by reduce tillage, N fertilization and irrigation can indicate that more sequestration of C from the atmosphere had occured under our rexperimental conditions.


THANK YOU