Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2012, 3 (11):5007-5012
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Effects zeolite and their integrated bio-fertilizer and different levels of chemical nitrogen fertilizer under irrigation management on yield and yield components of Peanut (*Arachis hypogaea L.)* In north of Iran

Maral Moraditochaee[1*], Ebrahim Amiri[2] and Ebrahim Azarpour[2]

[1]Young Researchers Club, Lahijan Branch, Islamic Azad University, Lahijan, Iran.
[2]Department of Agriculture, Lahijan Branch, Islamic Azad University, Lahijan, Iran

---

ABSTRACT

In order to determine the effect of zeolite mineral, bio-fertilizers and different levels of chemical nitrogen fertilizer under limited irrigation water management on peanut yield and its water use efficiency , a field experiment was conducted at Astaneh Ashrafiyeh province located at North of Iran. In 2010 growing season, Factorial split-plot in randomized complete block design with three replications was used. main plot was consisted of water regimes treatments (I_1=dry land and I_2=12 day Interval Irrigation) and sub factor was consisted of combination treatments of zeolite mineral (Z_1= 0 and Z_2=7 ton ha^{-1}), bio-fertilizers and different levels of chemical nitrogen fertilizer (N_1=0, N_2= Azospirillum + Azotobacter, N_3= 30 kg N ha^{-1}+ Aazospirillum + Azotobacter, N_4= 60 kg N ha^{-1}+ Aazospirillum + Azotobacter and N_5= 90 kg N ha^{-1}+ Aazospirillum + Azotobacter) was performed. The results of this investigation showed that all traits (seed yield, pod yield, biomass yield and water use efficiency based on seed, water use efficiency based on pod and water use efficiency based on biomass) were significantly affected by applying the suggested treatments. The highest seed yield was found to be on 12 day interval irrigation (2561 kg ha^{-1}), application of 7 ton ha^{-1} zeolie (2726 kg ha^{-1}) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (2345 kg ha^{-1}). The highest water use efficiency based on seed was found to be on 12 day interval irrigation (1.88 kg/m^3), application of 7 ton ha^{-1} zeolie mineral (1.73 kg/m^3) and application 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (2.03 kg/m^3).

Key Words: Peanut, Irrigation, Zeolite, Bio-fertilizer, Yield, Yield components.

INTRODUCTION

Peanut after soybean is one of the most important oil seed plants in tropical and sub-tropical regions that is planted often for its seeds rich in oil and protein. The oil of peanut is one of the most important vegetable oil in regions where other oily vegetables cannot grow up [11]. Increasing of global demands from one side and various productions and by-products from the other side determine the economic importance of this crop [16].

Surface irrigation is one of the oldest irrigation methods in which water is distributed as an open flow throughout a field. In fact, influenced by the gravity, water flows and moisturizes the whole surface of the field or part of it [18]. Infiltration is considered as one of the important parameters for designing irrigation systems based on which irrigation management and planning is done [17]. At the beginning, the infiltration rate is high, but in the long run, it gradually decreases until it reaches an approximately constant rate. Hence, the infiltration rate is of great significance in terms of irrigation because it is a determining factor for storing a certain amount of water in the soil. Final soil infiltration is the permeability which the soil shows in long durations. Moreover, during early stages, soil moisture is more effective on the infiltration rate. When air becomes stuck between the wetting front and the confining layer, its pressure increases and in turn, reduces the infiltration rate [18].

These properties have spurred their use for agronomic and horticultural applications as well [5]. Zeolites are natural minerals first discovered in 1756 by Swedish mineralogist, who named the porous minerals from the Greek words meaning "boiling stone" [10]. They are hydrated alominosilicates, characterized by three dimensional networks of SiO4 and AlO4 tetrahederal, liked by the sharing of all oxygen atoms. The partial substitution of Si+4 by Al+4 lead to an excess of negative charge which is compensated by cations. In structure of natural zeolite the water and cations can be reversibly removed or replaced by other cations [14]. Clinoptilolites are one kind of zeolites which are not the most well known yet, but are one of the most useful zeolites. Extensive deposits clinoptilolite are found in Western United State, Bulgaria, Hungary, Japan, Australia and Iran [10]. The size of clinoptilolite channels controls the size of the molecules or ions that can pass through them and therefore a zeolite like clinoptilolite can act as a chemical sieve allowing some iones to pass through while blocking others [10]. Amendment of clinoptilolite zeolite to sandy soils has been reported to lower nitrogen concentration in the leachate and to increase moisture and nutrients in the soil due to increased soil surface area and cation exchange capacity [8]. Additionally, clinoptilolite zeolite is a more permanent addition to the root zone, demonstrating good stability in weathering, impact and absorption tests [12].

Nitrogen has a critical role in producing agricultural products and selecting the amount of nitrogen-containing fertilizers is necessary for having the highest production level. Absorption of adequate amounts of nitrogen by a plant leads to more protein content and larger cereal and legume seeds. Generally, the more the concentration of nitrogen in leaves, the more the intensity of carbon-making would be because aside from being found as protein in plants, nitrogen is the main element in the chlorophyll synthesis and its fixation could lead to more growth of aerial parts. Usually, nitrogen shortage is observed when plant nutrition is not managed properly and this element is not provided in adequate amounts, which could result in the older leaves to turn yellow and eventually, the plant's growth stops. In other cases, when too much nitrogen is provided for the plant, it normally leads to watering of protoplasm and brittleness of the plant itself which would result in becoming vulnerable to diseases and pests [4]. Use of soil microorganisms which can whether fix atmospheric nitrogen or solubilize phosphates or synthesis of growth promoting substances or by enhancing the decomposition of plant residues to release vital nutrients and increase humic content of soils, will be environmentally begin approach for nutrient management and ecosystem function [21]. Effect of inoculation on soil: Soils are one of the most important resources a farmer has. Soil health is fundamental to profitable and sustainable production and most important resource we use in agriculture. Proper management of the soil is a key to plant health and crop productivity. Soil structure has a strong impact on a range of processes in xuencing crop yield. It refers to the manner and stability with which individual sand, silt, and clay particles are bound together into units called aggregates. Soil aggregation is an important characteristic of soil fertility. Aggregates determine the mechanical and physical properties of soil such as retention and movement of water, aeration, and temperature. Aggregate formation is an important factor controlling germination and root growth [14].

The present research was done to study the effects of zeolite mineral, bio-fertilizers and different levels of chemical nitrogen fertilizer under limited irrigation water management on on yield and yield components of Peanut (Arachis hypogaea L.) at Astaneh Ashrafiyeh province at the north of Iran.

MATERIALS AND METHODS

In order to determine effects of zeolite minerals, bio-fertilizers and different levels of chemical nitrogen fertilizer under limited irrigation water management on yield and yield components of peanut, a field experiment was conducted at Astaneh Ashrafiyeh province. It located at the north of Iran situated at 37◦ 16' and 46◦ 56' with an average altitude of 3m above the sea level using factorial split-plot in randomized complete block design with three replications in 2010 growing season. In this study main plot was consisted of water regimes; I_1=dry land and I_2=12 day Interval Irrigation and sub factor was consisted of combination of zeolites (Z_1= 0 & Z_2=7 ton/ha), bio-fertilizers and different levels of chemical nitrogen fertilizer (N_1=0, N_2= Azospirillum + Azotobacter, N_3= 30 kg N ha^{-1}+ Aazospirillum + Azotobacter, N_4= 60 kg N ha^{-1}+ Aazospirillum + Azotobacter and N_5= 90 kg N ha^{-1}+ Aazospirillum + Azotobacter) was performed. Based on soil analysis (Table 1), phosphorous and potash fertilizer were applied for all treatments. At first, the field was submitted for a complete tillage on May 7, 2010 and followed by creating ridges and furrows, cultivation of NC2 variety seeds started. Prior to cultivation, the seeds were disinfected in 2:1000 carboxin thiram as a fungicide [2]. Crop management operations included weeding (to control weeds) and side dressing around the root. Harvest was done on September 22, 2010. Surface irrigation method used in this research was of the ridges and furrows system type where the distance between the ridges was 75 cm with the distance between plants in each ridge being 30 cm .Azotobacter and Azospirillum used in this experiment were in the form of powder containing 108 Azotobacter and Azospirillum cells per 1 gram and packed in 1 kg cases. For applying Azotobacter and Azospirillum: First, a 20% solution of sucrose was made. Powder of Azotobacter and Azospirillum was added to it and completely mixed. Second, seeds were inoculated with such mixture.

Consumed water level during the growth period was determined through measuring the amount of irrigation water and the precipitation level. In order to measure the amount of water for irrigation for each experimental unit, a contour was used. For 12 days irrigation managements, 7 irrigation frequencies was considered, respectively in which 350 mm water was consumed. To determine the total biomass (dry matter) at maturity, after excluding two rows on both sides in each plot, 12 plants were randomly selected. Then, pods, leaves and stems were placed in a 70ºC oven for 48 hours. When dried, initially, mature pods' weight for each plant was measured by the ratio of mature pods weight to the number of mature pods per 12 plants. To estimate seed and pod yields, after the exclusion of two rows on the sides, mature pods and seeds were weighed using an accurate laboratory scale.

In maturity time plant height, 100 seed weight, Number pod per plant, Number seed per plant, pod length, seed length and harvest index were measured. Relative water content (RWC) was measured following Kramer [9], using the second fully expanded leaf from the top of the main stem. For variance analysis and the comparison of mean values (Duncan test, probability level of 5%) and in order to draw relevant diagrams, SAS and Excel software were used.

RESULTS AND DISCUSSION

Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizers and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the seed yield (Table 2). The highest seed yield were found to be on 12 day interval irrigation (2561 kg/ha), application of 7 ton ha^{-1} zeolite (2726 kg/ha) and application 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (3345 kg/ha) (Table 3). Results, also, show that irrigation water management (P<0.01), application of zeolite (P<0.01), bio-fertilizers and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the pod yield (Table 2). The highest pod yield were found to be on 12 day interval irrigation (4370 kg/ha), application of 7 ton ha^{-1} zeolite (4703 kg ha^{-1}) and application 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (5644 kg/ha) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the biomass yield (Table 2). The highest biomass yield were found to be on 12 day interval irrigation (12986 kg ha^{-1}), application of 7 ton ha^{-1} zeolite (13596 kg/ha) and application of 30, 60 and 90 kg N ha^{-1}+ Aazospirillum + Azotobacter (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the harvest index (Table 2). The highest harvest index were found to be on 12 day interval irrigation (33 %), application of 7 ton ha^{-1} zeolite (34 %) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (40 %) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the plant height (Table 2). The highest plant height were found to be on 12 day interval irrigation (74.55 cm), application of 7 ton ha^{-1} zeolite (72.54 cm) and application of 90 kg N ha^{-1}+ Aazospirillum + Azotobacter (86.29 cm) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the number of seed per plant (Table 2). The highest number of seed per plant were found to be on 12 day interval irrigation (89), application of 7 ton ha^{-1} zeolite (91) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (108) (Table 3). Results show that irrigation water management (P<0.01), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the number of pod per plant (Table 2). The highest number of pod per plant were found to be on 12 day interval irrigation (47.21), application of 7 ton ha^{-1} zeolite (51.33) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (61.74) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the 100 seed weight (Table 2). The highest 100 seed weight were found to be on 12 day interval irrigation (38.58 g), application of 7 ton ha^{-1} zeolite (39.72 g) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (42.11 g) (Table 3). Results show that irrigation water management (P<0.01), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the root length (Table 2). The highest root length were found to be on 12 day interval irrigation (22.08 cm), application of 7 ton ha^{-1} zeolite (22.13 cm) and application of 0 kg N ha^{-1}+ Aazospirillum + Azotobacter (26.25 cm) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the seed length (Table 2). The highest seed length were found to be on 12 day interval irrigation (4.08 cm), application of 7 ton ha^{-1} zeolite (3.88 cm) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (4.2 cm) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.05), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.01) had a significant effect on the seed width (Table 2). The highest seed width were found to be on 12 day interval irrigation (2.32 cm), application of 7 ton ha^{-1} zeolite (2.2 cm) and application of 30 kg N ha^{-1}+ Aazospirillum + Azotobacter (2.72 cm) (Table 3). Results show that irrigation water management (P<0.05), application of zeolite (P<0.01), bio-fertilizer and different levels of chemical nitrogen fertilizer (P<0.05) had a significant effect on the RWC (Table 2). The highest RWC were found to be on 12 day interval irrigation (85.6 %), application of 7 ton ha^{-1} zeolite (86.4 %) and application of 0, 30, 60, 90 kg N ha^{-1}+ Aazospirillum + Azotobacter (Table 3).

Songsri et al. [19] observed that moisture content difference in surface layers was quite apparent, while in lower layers this difference for irrigation managements was negligible in a way that moisture rates were corresponding during the growth period. The processes of biological fixation of nitrogen by organisms of the Rhizosphere play an important role in increasing crop production with addition amount of nitrogen in soil around plant roots. This nitrogen have helped in improving growth and hence increased leaf area that intercept light and increased photosynthetic rates resulting in the accumulation of more dry matter by the crop. Inoculation Azospirillum and Azotobacter along with 30 kg ha^{-1} nitrogen application cause to increase of nitrogen consumption efficiency and preparation better condition for nutrient uptake by plant and also optimum growth and development of groundnut. A number of bacterial species belonging to genera Azospirillum, Alcaligenes, Arthrobacter, Acinetobacter, Bacillus, Burkholderia, Enterobacter, Erwinia, Flavobacterium, Pseudomonas, Rhizobium and Serratia are associated with the plant rhizosphere and are able to exert a beneficial effect on plant growth [6, 20]. The important role is played by plants in selecting and enriching the types of bacteria by the constituents of their root exudates. Thus, the bacterial community in the rhizosphere develops depending on the nature and concentrations of organic constituents of exudates, and the corresponding ability of the bacteria to utilize these as sources of energy [3]. There is a continuum of bacterial presence in soil rhizosphere, rhizoplane and internal of the plant tissues [7]. Rhizospheric bacterial communities however have efficient systems for uptake and catabolism of organic compounds present in root exudates [1]. After establishing in the rhizosphere, Azospirillum and Azotobacter usually, but not always, promote the growth of plants. Although they posses N_2-fixing capability (~1–10 kg N/ha), the increase in yield is mainly attributed to improved root development due to the production of growth promoting substances and consequently increased rates of water and mineral uptake [15]. The approach to revegetation described here uses a zeolite known as clinoptilolite to raise shallow groundwater by capillary action to or near the soil surface for use by plants.

Table 1. Some chemical and physical properties of soil of the experimental location

Potassium (ppm)	Phosphorus (ppm)	Nitrogen (%)	pH	Organic carbon (%)	Soil texture
215	1.12	0.074	6.5	0.67	Sandy Loamy

Table 2. Results of variance analysis for effects of zeolite, bio-fertilizers and different levels of chemical nitrogen fertilizer under irrigation water management on yield and yield components

S.O.V	DF	Seed Yield	Pod yield	Biomass yield	Harvest index	Plant height	Root Length
Replication (R)	2	342.07	414.05	765.27	16.18	70.23	247.252
Irrigation (I)	1	1269.6*	1782.15**	3088.82*	80.99*	3283.97*	16.579**
R×I	2	22.05	10.55	135.27	22.55	99.72	0.147
Zeolite (Z)	1	2208.27**	3697.35**	5208.02**	344.44**	1745.17**	19.906**
Nitrogen + Bacteria (N)	4	987.57**	1611.79**	2876.6**	361.26**	1704.92**	170.195**
I×Z	1	13.07	16.02	814.02	121.39	712.56	0.01
I×N	4	27.6	50.02	54.44	38.09	208.50	0.101
Z×N	4	65.52	73.8	24.89	92.46	430	0.14
I×Z×N	4	22.15	40.8	16.55	19.32	91.15	0.00005
Error	36	47.52	70.68	133.51	27.76	134.19	2.094
CV	2	15.16	14.07	10.82	16.9	17	6.7
S.O.V	**DF**	**Number of seed per plant**	**Number of pod per plant**	**100 seed weight**	**Seed length**	**Seed width**	**RWC**
Replication (R)	2	4.46	455.20	59.4	0.04	0.06	76.12
Irrigation (I)	1	34.2*	1257.11**	776.01*	7.42*	2.6*	2937.2*
R×I	2	1.11	20.96	69.07	0.48	0.13	178.3
Zeolite (Z)	1	43.33**	4540.35**	1341.9**	1.48**	0.43*	3669.45**
Nitrogen + Bacteria (N)	4	23.74**	2118.26**	337.55**	1.56**	1.72**	535.54*
I×Z	1	0.07	53.39	114.15	0.06	0.08	281.58
I×N	4	1.06	22.71	8.27	0.004	0.04	260.7
Z×N	4	3.76	218.70	14.78	0.02	0.46	61.642
I×Z×N	4	0.02	56.85	3.71	0.04	0.06	17.167
Error	36	1.27	109.523	11.03	0.07	0.1	139.95
CV	2	11.97	20	9.49	7.4	15.14	15

*ns, ** and * respectively: non significant, significant in 1% and 5% area*

Table 3. Comparison among means of the obtained-outputs of zeolite, bio-fertilizers and different levels of chemical nitrogen fertilizer under irrigation water management on yield and yield components

S.O.V	Seed Yield (Kg/ha)	Pod Yield (Kg/ha)	Biomass yield (Kg/ha)	Harvest Index (%)	Plant Height (cm)	Root length (cm)
Irrigation (I)						
I_1	1726B	3065B	10263B	29B	59.75B	21.02B
I_2	2561A	4307A	12986A	33A	74.55A	22.08A
Zeolite (Z)						
Z_1	1661B	2733B	9653B	29B	61.75B	20.97B
Z_2	2726A	4703A	13596A	34A	72.54A	22.13A
Nitrogen + Bacteria (N)						
N_1	1174C	2082C	7363C	29CB	55.06C	23.96B
N_2	1468C	2062C	9203B	29CB	63.24CB	26.25A
N_3	3345A	5644A	13889A	40A	63.24CB	20.86C
N_4	2256B	4508B	13533A	32B	69.9B	18.92D
N_5	2174B	3753B	14135A	25C	86.29A	17.36E
	Number of seed per plant	Number of pod per plant	100 seed weight (g)	Seed length (cm)	Seed Width (cm)	RWC %
Irrigation (I)						
I1	62B	38.05B	31.39B	3.37B	1.9B	71.6B
I2	89A	47.21A	38.58A	4.08A	2.32A	85.6A
Zeolite (Z)						
Z1	60B	33.93B	30.36B	3.57B	2B	70.8B
Z2	91A	51.33A	39.72A	3.88A	2.2A	86.4A
Nitrogen + Bacteria (N)						
N1	49C	29.98C	29.06C	3.3D	1.76C	68.9B
N2	52C	31.27C	30.59C	3.47B	1.85C	75.3A
N3	108A	61.74A	42.11A	4.2A	2.72A	86.3A
N4	91AB	49.15B	37.64B	3.94B	2.18B	80.8A
N5	77B	41.31B	35.53B	3.71C	2.03B	81.7A

Within each column, means followed by the same letter do not differ significantly at P<0.05

REFERENCES

[1] WL Barraquio, EM Segubre, MS Gonzalez, SC Verma, EK James, JK Ladha, AK. Tripathi, **2000**, Diazotrophic enterobacteria: What is their role in the rhizosphere? In The Quest for Nitrogen Fixation in Rice, IRRI, Manila. Edited by Ladha JK, Reddy PM, 93-118.
[2] PQ Craufurrd, PV Vara, RJ. Summerfield **2002**, *Crop Sci*, 42, 146-151.
[3] EA Curl, B. Truelove, **1986**, The Rhizosphere. Springer Verlag, Berlin-Heidelberg, 1-288.
[4] MH. Davoodi, **2007**, Nutrient Macroelements Deficiency Symptoms in Field Crop. Agriculture Education publication, 1-144.
[5] IM. Dwairi, **1998**, Evaluation of Jordanian zeolite tuff as a controlled slow-release fertilizer for NH4, Environmental Geology, 34, 1-3.
[6] D. Egamberdiyeva, **2005**, *Journal of Plant Nutrition and Soil Science*, 168(1), 94-99.
[7] J Hallmann, A Quandt-Hallmann, WF Mahaffee, JW. Kloepper, **1997**. *Canadian Journal of Microbiology*, 43(10), 895-914.
[8] ZL He, DV Calvert, AK Li, DJ. Alva-Banks, **2002**, *Plant and Soil*, 247:253-260.
[9] PJ. Kramer, **1980**, Drought stress and the origin of adaptation. In: N. C. Turner, P. J. Kramer (eds), Adaptation of Plant to Water and High Temperature Stress, 7-20. John Wiley & Sons, New York.
[10] FA. Mumpton, **1999**, La roca magica: Uses of natural Zeolite in agriculture and industry. Proceeding of the National Academy, 96, 3463-3470.
[11] K Norman, L Wieck, P Harden, G. Baker, **2005**, Peanut production guide. National Library of Australia Cataloguing-in-Publication Data, 36.
[12] CH Ok, SH Anderson EH. Ervin, **2003**, *Agronomy Journal*, 95, 1583-1590.
[13] M Rehakova, S Cuvanova, M Dzivak, J Rimarand, Z. Gavalova, **2004**, *Current Opinion in Soil State and Materials Science*. 8, 397-404.
[14] AM Rhawhia, TA El-Rahmany, BF Abd El-Ghany, MM El-Shazly, M. Morsy, **2010**, *Research Journal of Agriculture and Biological Sciences*, 6(3), 228-246.
[15] BS Saharan, V Nehra, **2011**, *Life Sciences and Medicine Research*, 1-30.
[16] J. Smart, **1994**, The groundnut crop: A scientific basis for improvement, London, Chapman and Hall, 734.
[17] B Sohrabi, A. Behnia, **2007**, *Journal of Agronomy*, 6(3), 468-471.
[18] T Sohrabi, Z. Paydar, **2009**, Principles of Irrigation System Design. University of Tehran publication. 406.
[19] P Songsri, S Jogloy, T Kesmala, N Vorasoot, C Akkasaeng, A Patanothai, C. Holbrook, **2008**, Heritability of

drought resistance traits and correlation of drought resistance and agronomic traits in peanut, Crop Science Society of America, 48, 2245-2253.
[20] KVBR. Tilak, N Ranganayaki, KK Pal, R De, AK Saxena, CS Nautiyal, S Mittal, AK Tripathi, BN. Johri, **2005**, *Current Science*, 89(1): 136-150.
[21] SC Wu, ZH Cao, ZG Li, KC Cheung, MH. Wang, **2005**, Effects of biofertilizer containg N-fizer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial, Geoderma, 125(2), 155-166.