



WOLKITE UNIVERSITY
COLLEGE OF AGRICULTURE AND NATURAL
RESOURCES

DEPARTMENT OF HORTICULTURE

Growth and Yield Response of Chinese red Lettuce to *Different NPS Rates*
at Wolkite University Research Site

By	ID No
Ejegayohu Kidane.....	AGR/112/09
Girma Shela.....	AGR/155/09
Yeshimebet Tamir.....	AGR/327/09

Advisor: Mr, Abraham (MSc.) in Horticulture

A Senior Research Project Proposal

*Submitted to Department of Horticulture Wolkite University College of
Agriculture in Partial fulfillment of the requirements for the course senior
research project (Hort 1351)*

January, 2019
Wolkite, Ethiopia

ACKNOWLEDGEMENT

Above all, we thank our God a debt of praise for his presence with us in all ups and downs. Next we would like to express our great thanks to Wolkite University College of Agriculture and particularly Department of Horticulture for preparing such type of learning activity. Our special thanks also go to our advisor Mr. Abraham Mulatu (MSc). For his unreserved advice and frequent supervision in the entire work of our Research project proposal writing.

TABLE OF CONTENT

Contents	page
ACKNOWLEDGEMENT	i
TABLE OF CONTENT	ii
LIST OF TABLES	iii
ABBREVIATIONS	iv
1. INTRODUCTION	1
1.1. Statement of the problem.....	2
1.2. Significance of the study.....	2
1.3. Objectives	3
2. LITERATURE REVIEW	3
2.1. The Chinese red Lettuce Crop	3
2.2. Environmental factor affecting growth of Chinese red lettuce.....	4
2.2.1. Light and nutrients	4
2.2.2. Temperature	5
2.3. Effect of NPS on lettuce growth performance.....	5
3. MATERIAL AND METHODS	6
3.1. Description of the Study Area.....	6
3.2. Experimental Material	7
3.3. Treatments and Experimental Design.....	7
3.4. Seed bed preparation and transplanting.....	8
3.4.1. Seed bed preparation	8
3.4.2. Transplanting.....	8
3.4. Field Management	9
3.6. Data to be collected.....	9
3.6. Methods of Data Analysis.....	10
4. WORK PLAN	11
5. LOGISTICS	12
REFERENCES	14

LIST OF TABLES

Table	Pages
Table 1. Treatment Combinations	7
Table 2: Work Plan.....	Error! Bookmark not defined.
Table 3: Personal costs	12
Table 4: Equipments and Input cost	Error! Bookmark not defined.
Table 5: Stationery cost	Error! Bookmark not defined.
Table 6: Budget summary	Error! Bookmark not defined.

ABBREVIATIONS

FAO	Food and Agricultural Organization
LSD	Least Significance Difference
RCBD	Randomized Complete Block Design

1. INTRODUCTION

Chinese red Lettuce an annual plant of Composite family is one of the most important vegetables in human diet. It is an important leafy salad vegetable, rich in vitamins and minerals, that is mainly grown in cool season of the year in tropical and sub-tropical countries (Rahman *et al.*, 1997). Lettuce is grown mainly as a salad crop, but the leaves may be boiled just like spinach. The composition of lettuce leaves is approximately 94.3% water, 1.2% protein, 0.2% fat, 2.9% carbohydrate (CHO), 0.7% fiber and 0.7% ash. It is rich in vitamin A, C and E and minerals such as calcium, phosphorus, sodium, magnesium and potassium. Lettuce esteemed for its flavour rather than for its nutrient value (Raymond, 1997). Lettuce is one of the most important vegetable crops in temperate countries. However, it occupies an important position for its cultivation in tropical and subtropical countries also. Lettuce occupies the largest area among salad crops and thus it is the most important salad crop of the world (Bose, 1990).

Lettuce is a relatively recent introduced into the tropics. Soil health is a crucial factor for realizing higher yield of vegetables. This vegetable requires a very moist environment and a sandy or loamy soil, a high rate of NPS for growth and development (Virgine Tenshia and Singram, 2005). The optimum mean temperature range for excellent growth and good quality of lettuce is 15-25°C and temperature above 25°C accelerates seed stalk and reduces the quality of leaves (Rashid, 1999). It is evident that high air temperature causes high soil temperature, which retards root growth and affects the uptake of water and nutrients and photosynthesis that consequently results in stunted plant growth and mortality (Firoz *et al.*, 2000). As there is a great difference between the tropical and temperate environments in terms of temperature, light and humidity, there may be some differences in management practices including planting density and nutrient application levels.

Among the factors that affect yield and quality of lettuce, population or plant density is one of the most important elements. Lettuce yield usually varies with different plant densities. Lettuce an annual leafy herb belongs to the family of *Asteraceae/ Compositae* is one of the most popular salad crops and occupies the largest production area among salad crops in the

world. Lettuce is ranked 26th among vegetables and fruits in terms of nutritive value and 4th in terms of consumption. It is the most popular salad crop in the world and because of used crude, its vitamins inter to human body without change. The nutrient content is highest in the darker green, outer leaves (FAO, 2009). It is popular for its delicate, crispy texture and slightly bitter taste with milky juice as fresh condition. It is the most popular amongst the salad vegetable crops (Squire *et al.* 1987).

1.1. Statement of the problem

Lettuce occupies the largest area among salad crops and thus it is the most important salad crop of the world (Bose, 1990). It also cultivated in some part of our country. Power and Schepers (1989) showed that vegetables require a greater degree of management and utilize a larger NPS input than most agronomic cropping systems. Lawrence and Smittle (1998) stated that vegetables recover less NPS than agronomic crops, and, by consequence, the potential for NO₃ loss is greater with the former. The use of fertilizer is considered to be one of the most important factors to increase growth and crop yield, however; the recommended rate of NPS vary from area to area based on the soil condition of the locality. Both over and under application of nitrogen could adversely affect the growth, yield and yield response of lettuce. It is an important leafy salad vegetable, rich in vitamins and minerals, that is mainly grown in cool season of the year in tropical and sub-tropical countries (Rahman *et al.*, 1997). Lettuce is a newly introduced crop in tropic (Ethiopia) and its production package is almost unknown. As there is a great difference between the tropical and temperate environments in terms of temperature, light and humidity, there may be some differences in management practices including planting density and nutrient management. Among the factors that affect yield and quality of lettuce, population or plant density is one of the most important elements. Lettuce yield usually varies with different plant densities (Adu-Sankode, 1980).

1.2. Significance of the study

Lettuce crop requires a high rate of NPS for growth and development. Despite its importance for the growth of lettuce NPS is highly mobile element which is not sufficiently found in the soil for the growth performance of lettuce. Lettuce is not like a leguminaceae crop that can fix NPS from the air and it is shallow rooted crops which are not search nutrient from distance.

Plant density is also other major factors that affect the growth and yield of lettuce crop. Increasing in plant population also increase competition between plant for nutrient, space, light, moisture etc, which adversely affects the crop. That is why we are more interested to conduct our research on growth performance and yield of lettuce in relation to different NPS fertilizer between plants. This research can be used for coming students as a reference, for further research in the future and the way of review different research done on this issue, on the other hands also used the farmers or the society who working on agricultural area.

1.3. Objectives

- To evaluate the effect of Different NPS rate fertilizer on the growth and yield Response of Chinese red lettuce
- To identify optimum different NPS level that enhances the growth performance and yield of Chinese red lettuce

2. LITERATURE REVIEW

2.1. The Chinese red Lettuce Crop

Chinese red Lettuce an annual plant of Composite family is one of the most important vegetables in human diet. It is the most popular amongst the salad vegetable crops (Squire *et al.*, 1987). In line with investigations carried out by Rashid (1999) in USA, lettuce ranked 26th among vegetables and fruits in terms of nutritive value and 4th in terms of consumption rate highlighting the ever-increasing importance of this crop. Lettuce normally consumed raw and has a high nutrient value, being rich in calcium, iron and vitamin A. It is a good source of vitamins and often prescribed to weight conscious consumers because of its low kilojoules content (Maboko, 2007). It is one of the most important vegetable crops in temperate

countries. However, it occupies an important position for its cultivation in tropical and subtropical countries also. Lettuce occupies the largest area among salad crops and thus it is the most important salad crop of the world (Bose, 1990). Lettuce is a cool season crop. The optimum mean temperature range for excellent growth and good quality of lettuce is 15-25°C and temperature above 25°C accelerates seed stalk and reduces the quality of leaves (Rashid, 1999). During crop growth a number of factors may affect vegetable quality and quantity. Improving the growth factors is crop quality and quantity key. Thus, growers need to increase their production by adopting appropriate strategies and techniques, which will lead to sufficient and reliable yields. This vegetable requires a high rate of NPS for growth and quality (Kobryn, 1987).

2.2. Environmental factor affecting growth of Chinese red lettuce

Plants have a remarkable capability to adapt and grow effectively in a wide range environment. They do so by changing their morphological and physiological characteristics in response to the environmental conditions of growth (Lambers *et al.*, 1990). Growth and development of field crops, grown with optimal water and nutrient supply, are largely controlled by the effects of the environmental factors, such as temperature, radiation and day length, upon plant growth habit, dry matter partitioning and canopy structure and hence on the interactions between genotype and agronomic practices, such as sowing times and density (Hay and Walker, 1989).

2.2.1. Light and nutrients

Light and nutrition are two such features of the environment that affect growth. Growth is determined by the available incident radiation, the proportion of radiation absorbed by the canopy and the efficiency by which absorbed radiation is converted into biomass (Barneix, 1990). Hirose and Werger (1987) showed the existence of a symbiotic relationship between photosynthetic rate and leaf nitrogen content. This means that there is a range over which relatively large increases in leaf nitrogen content will give only marginal increases in the photosynthetic rate and carbon gain. However, carbon gain can also increase by nitrogen investments in canopy expansion resulting in more light interception. Light is regarded as a primary factor regulating plant growth and development (Gaudreau *et al.*, 1994). Sudden

changes to very sunny and dry weather after an extended darker and more humid period promote the occurrence of tip burn. Tip burn does not occur under conditions of low light intensity or extended periods of darkness. Tip burn, which appears during head formation, is a disorder associated with low calcium levels and causes young leaves to become brown and to have necrosis beginning at the leaf margins (Collier and Tibbitts, 1982). Head formation is a major standard of lettuce quality and is stimulated by suitable light and temperature conditions (Gaudreau *et al.*, 1994).

2.2.2. Temperature

Temperature in the root zone also affects the uptake of Ca (calcium). The uptake of Ca increases between 14 and 26°C, but at higher root temperature, it will be reduced (Adams & Ho, 1993). Higher temperature enhanced tip burn incidence by promoting growth and, thus, reducing stress tolerance (Saure, 1998). Therefore, the severity of tip burn may be caused by extremes of root temperatures. Tip burn may be a big problem for the production of Chinese cabbage and lettuce in subtropical and tropical regions during the hot season. Therefore, in these regions place and time of commercial plantings usually are chosen to avoid hot weather around harvest time. Apparently, there is a greater risk of tip burn if there is a change in temperature, with a sudden period of warm weather after an extended period at lower temperature, or several days of high temperature together with low humidity (Saure, 1998).

2.3. Effect of NPS on Chinese red lettuce growth performance

Plants have a remarkable capability to adapt and grow effectively in a wide range of environments. They do so by changing their morphological and physiological characteristics in response to the environmental conditions of growth (Lambers *et al.*, 1990). Nutrition is one such feature of the environment that affects growth. Effects of NPS on growth might result from effects on photosynthetic rate and/or on leaf area (Grindlay, 1997). Hirose and Werger (1987) showed the existence of an asymptotic relationship between photosynthetic rate and leaf nitrogen content. This means that there is a range over which relatively large increases in leaf nitrogen content will give only marginal increases in the photosynthetic rate and carbon gain. However, carbon gain can also increase by NPS investments in canopy expansion resulting in more light interception.

In several studies (McDonald *et al.*, 1986a), the main effect of NPS on growth was in fact through effects on leaf area. Photosynthesis was of secondary importance in the attainment of crop biomass. The final effect will depend on the relative advantages for whole plant carbon gain of using NPS to increase the leaf photosynthetic capacity or to produce more leaf area for light interception (Grindlay, 1997). Novoa and Loomis (1981) proposed that the demand for nitrogen is determined by growth rate and the nitrogen composition of new tissue (Grindlay, 1997). The investigations carried out by (Tittonell *et al.*, 2003) on lettuce showed that increasing NPS fertilizer from 0-150kg ha⁻¹ increased the fresh weight of the crop. The investigation conducted by Mahmoudi Kliber (2005) on lettuce showed that by increasing the rate of NPS fertilizer to 180kg ha⁻¹ increased the yield and dry matter of lettuce but between 100 and 120kg ha⁻¹ was not significantly different. However, the yield response of lettuce to increasing NPS rate varies with different environmental variables, including weather, soil type, residual fertility, soil moisture, seasons and cultivar.

Naser Alemzadeh (2007) stated that the highest yield was obtained with 120kg ha⁻¹ nitrogen fertilizers. According to McDonald (1990), this is impossible unless the required stability of plant nutrition (constant nutrient concentration in the plant) has been established. Only then is it ensured that any changes observed are associated with decreased nitrogen supply (and not just plant size or age) allowing that the effect of a further variable such as irradiance becomes quantifiable.

3. MATERIAL AND METHODS

3.1. Description of the Study Area

The study will be conducted at Wolkite University Agriculture and Natural resource research site in 2011 E.C. Wolkite, the capital city of Gurage Zone, is 170 km away from Addis Ababa to South west direction. Wolkite comprises an attitude ranging from 1300 meters above sea level. The mean annual temperature ranges from 14 to 24⁰c with an average of 20-25⁰c. The soil type of the area heavy vertisol around 80% which is rich in organic matter while less capability to drain water. The rain fall of Wolkite is bimodal in which 80% of rain falls in

Kreft period of June to August where as 20% in the Belg period of February to May (GZADD, 2011).

3.2. Experimental Material

In this experiment Chinese red lettuce variety will be used as an experimental material. After preparing the nursery bed with a fine tillage of the soil sowing will be done. Sowing of seeds will be done at a depth of about 2cm and cover them lightly with soil. The nursery bed will be covered with a thin layer of mulch. Watering the nursery bed will be done every day. Seedlings will be transplanted about five weeks after sowing.

3.3. Treatments and Experimental Design

The treatments will consist of 6x3 factorial combinations of different NPS fertilizer (0, 50, 100,150,200 and 250 kg/ha) and row to row and plant to plant spacing (70x30cm). Details of the treatment combinations are shown in Table 1. The experiment will be laid out in a randomized complete block design (RCBD) in a factorial arrangement and three replication. Thus there will be 6 treatment combinations which will account for 18 experimental plots. Raised plot will be prepared with a size of 4.2 m by 2.1 m in width and length, respectively. Spacing of 0.5 m between plots and 1 m between blocks will be maintained for cultural operations. Plants in the middle four rows will be used for data collection, leaving aside those at the border rows as well as those at both ends of each row.

Table 1. Treatment Combination

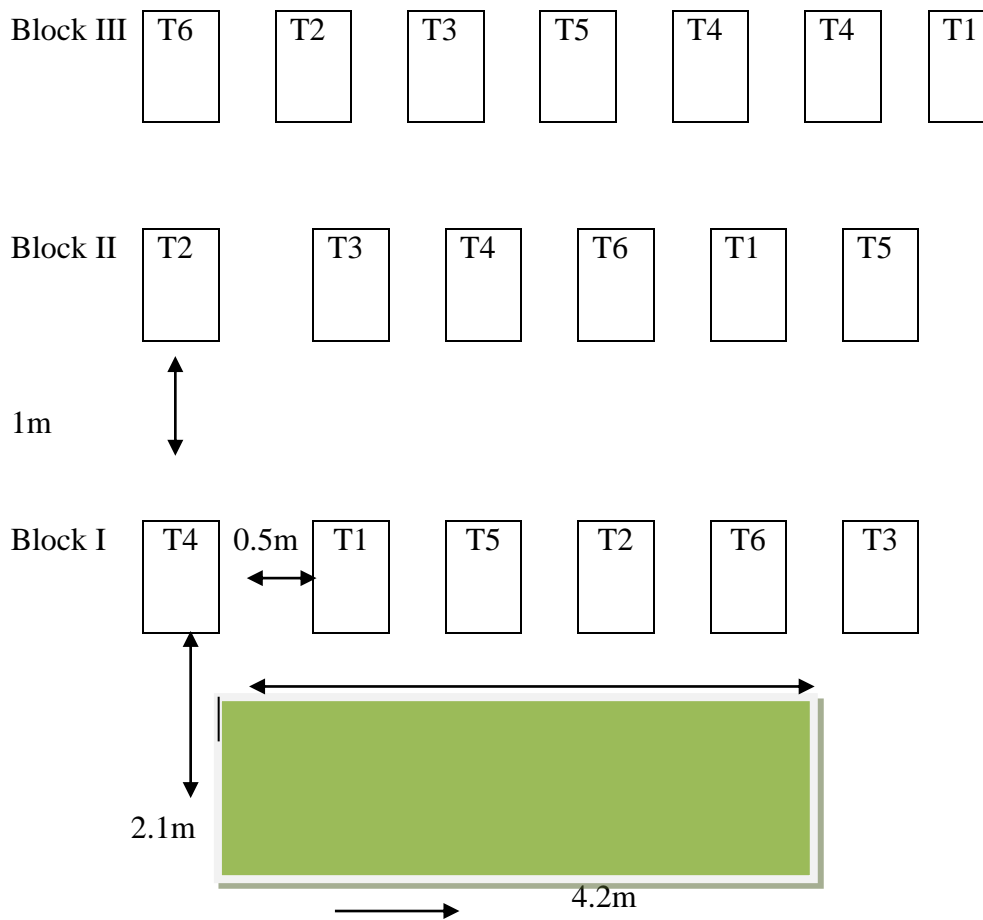


Fig.1. Field plot plan

3.4. Seed bed preparation and transplanting

3.4.1. Seed bed preparation

The nursery bed will be prepared by pulverizing the soil very well. The seeds will be sowed at a depth of 2cm and covered lightly with soil. Then the nursery bed will be covered with a thin layer of mulch. The nursery bed will be watered and soil moisture will be kept at field capacity. The beds will be shaded to protect the young plants from direct sunlight and strong wind.

3.4.2. Transplanting

Seedlings will be transplanted about five weeks after sowing. Seedlings will be watered about an hour before uprooting them from the nursery, in order to prevent root damages. Transplanting will be done on a cloudy day or late in the evening when the sun is cool. The experimental field will be ploughed the land about a month in advance. For proper drainage and root development, the beds will be raised at height of 5cm. During transplanting, DAP will be incorporated with soil in order to help improve on nutrient uptake, stimulate root development, and add organic matter to the soil, among other benefits. Beds will be watered and seedlings will be planted at the same depth while in the nursery.

3.4. Field Management

Seeds of Chinese red varieties will be selected as planting materials and sowed at the depth of 12cm after six days of land preparation and watering will be carried out two times a day i.e. early in the morning and early in the afternoon. All agronomic practices other than the recommended treatment variables will be applied according to the standard practices recommended for the Lettuce crop will be done accordingly.

3.6. Data to be collected

Both growth and yield component data of lettuce will be collated from four central (row) by selecting representative plant sample randomly on the basis as described below.

Plant height (cm): It will be measured from the ground level to the top most growth point above ground after the plants reached at maximum vegetative stage by using rural.

Leaf Length (cm): The lengths of leaves will be measure by using a ruler. The measurements will take from base (end of sheath) to tip of the three leaves of each plant. Average length of leaves will be taking from six select plants in centimeter (cm).

Number of leaf per plant: visual counting of leaf on randomly taken plants will be recorded for each plant by using our hands. Every visible leaf on the plant, including the tips of new leaves will be count.

Plant width (cm): It will be measured from middle rows of the plot and the measurements will take from base (end of sheath) to tip of the three leaves of each plant. Average width of leaves will be taking from six select plants in centimeter (cm).

Fresh weight measuring (g): plants will removed from soil and wash off any loose soil and Blot plants gently with soft paper towel to remove any free surface moisture and Weigh immediately by using sensitive balance.

Canopy (cm): it will be measured from cross section of randomly selected Chinese red lettuce leaves using centimeter.

3.6. Methods of Data Analysis

All variables will be subjected to the analysis of variance using (GenStat version 13.0) software. Least significance difference (LSD) at 5% will be used to separate means.

4. WORK PLAN

Table-2.work plan (fromDecember –June) 2019.G.C

No	Activities	December	January	February	March	April	May	June
1	Proposal title selection							
2	Proposal development	✓						
3	Proposal first submission		✓					
4	Proposal final submission		✓					
5	Defense proposal		✓					
6	Site selection and preparation			✓				
7	Planting			✓				
8	Watering, fertilizing, weeding			✓	✓	✓		
9	Data collection				✓	✓		
10	Data entry, processing analysis and paper write up					✓	✓	✓
11	Report writing			✓	✓	✓	✓	✓
12	Final submission of paper to the department							✓
13	Presentation							✓

5. LOGISTICS

5.1. Personal costs

Table -3. Personal cost (February-June), 2019

Qualification	Quantity	Duration(month)	Payment rate(Birr)	Total cost(Birr)
Daily laborer	3	2	30/day	1800
Adviser	1	1	50/ day	1500
Sub total				3300

5.2. Equipment's and input cost

Table – 4. Equipment's and supplies cost (February-June), 2019

Item	Unit	Quantity	Unit cost in birr	Total
Lettuce seed	Gm.	25	45	45 birr
Tape meter	M	1	60	60 birr
Rope	M	2	20	40 birr
Spade	No.	1	25	25 birr
DAP	Gm.	500	10	5 birr
Hoe	No.	1	20	20 birr
Subtotal				195 birr

5.3 Stationary

Table -5. Stationary cost

Item	Unit	Quantity	Unit cost (Birr)	Total cost (Birr)
Record book	-	1	25	25
Pen	-	6	5	30
Paper	-	150	0.35	52.5
Ruler	-	2	10	20
CD.R	-	3	8	24
Flesh		1	200	200
Sub total				351.5

5.4 Budget summary

Table-6. Budget summary

Item	Sub total
Personal cost	3300
Equipment's and supplies cost	3150
Stationary cost	351.5
Contingency (5%)	340.075
Total	7141.60

REFERENCES

Adams, P. & Ho, L.C. 1993. Effects of environment on the uptake and distribution of calcium in tomato and the incidence of blossom-end rot. *Plant and soil* 154, 127-132.

Andrews M (1986) The partitioning of nitrate assimilation between root and shoot of higher plants. *Plant Cell Environ.* 97:511–519

Andriolo, J.L., Godoi, R.S., Cogo, C.M., Bortolotto, O.C., Luz, G.L. & Madaloz, J.C., 2006. Growth and development of lettuce at high NH₄⁺: NO₃⁻ ratios in the nutrient solution. *Hortic. Bras.* 24, 352-355.

Anon, (1954). Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook, No: 60, USA, p. 160.

Barneix AJ. 1990. Yield variation in wheat: NPS accumulation, light interception and harvest index. In: Lambers H, Cambridge ML, Konings H, Pons TL, eds. Causes and consequences of variation in growth rate and productivity of higher plants. The Hague: SPB Academic Publishing, 87±100.

Bolan NS, Hedley MJ, White RE (1991) Processes of soil acidification during nitrogen cycling with emphasis on legume based pastures. In: Wright RJ, Baligar VC, Murrmann RP (eds.). Plant-soil interactions at low pH. Kluwer Academic Publishers, Dordrecht

Bose, T., M. Som and J. Kabir. 1990. Vegetable crops in India. Noya Prokash, Calcuta, India

Bpedors.2000. Physical and Social Economic Profile of 180 District of Oromia Region.

Collier, G.F. & Tibbitts, T.W. 1982. Tipburn of lettuce. *Horticultural Reviews* 4:49-65.

Collingwood, E.F., 1988. Vegetable Production under Arid and Semi-arid Conditions in Tropical Africa, Food and Agricultural Organization.

Crops Research Institute for Semi-Arid Tropics, Patancheru, Hyderabad

Epstein E, Bloom AJ (2005) Mineral Nutrition of Plants: Principles and Perspectives, 2nd Edition Sinauer, Sunderland, MA.

FAO statistics. 2009. Production Year book 2009. Food and Agriculture Organization of the United Nations, Rome. Italy.

Forde BG, Clarkson DT (1999) Nitrate and ammonium nutrition of plants: physiological and molecular perspectives. *Adv Bot Res.* 30:1–90

Gaudreau, L., Charbonneau, J., Vezina, L.P. & Gosselin, A. 1994. Photoperiod and photosynthetic Photon Flux Influence Growth and Quality of Greenhouse-Grown Lettuce. *Horticultural Science* 29 (11) 1285-1289.

Grindlay DJC. 1997. Towards an explanation of crop nitrogen demand based on the optimisation of leaf NPS per unit leaf area. *Journal of Agricultural Science* 128: 377±396.

Hay RKM, Walker AJ. 1989. An introduction to the physiology of crop yield. UK: Longman Scientific & Technical

Hirose T, Werger MJA. 1987. NPS use efficiency in instantaneous and daily photosynthesis of leaves in the canopy of a *Solidago altissima* stand. *Physiologia Plantarum* 70: 215±222.

In: Proceedings of 7th International Workshop, 7-11 April, 1986, International

Jones, J. B., W. Benjamin and A.M. Harry, 1991. *Plant Analysis Handbook; A Practice sampling, preparation, Analysis with interpretation Guide*, Micro - macro publishing Inc. U.S.A.

Kobryn, J. 1987. Productivity of some crisp head lettuce cultivars in relation to sowing date and plant density in Autumn- Winter greenhouse production. *Eeszty Nacekowe Akadimii*

Rolnictej VBin. Hugona Kollataj-w-Krakowie Ogrednictwo. Warsaw Poland 210.

Kochhar, S.L., 1986. Tropical Crops a Textbook of Economic Botany. Meacmillian London.

Kotsiras A, Olympios CM, Drosopoulos J, Passa HC (2002) Effects of nitrogen form and concentration on the distribution of ions within cucumber fruits. *Sci Hort.* 95:175–183

Kraus TH, Warren SL (2002) Nitrogen form affects growth, mineral content, and root anatomy of *Cotoneaster* and *Rudbeckia*. *Hort Sci.* 37:126–129

Lambers H, Freijssen N, Poorter H, Hirose T, Van der Werf A. 1990. Analyses of growth based on net assimilation rate and nitrogen productivity. Their physiological background. In: Lambers H, Cambridge ML, Konings H, Pons TL, eds. Causes and consequences of variation in growth rate and productivity of higher plants. The Hague: SPB Academic Publishing, 1±1

Lowrance, R. and D. Smittle, 1998. Nitrogen cycling in a multiple cropvegetable production system. *J. Environ. Qual.*, 17:158-162.

Maboko, M.M., 2007. Leafy lettuce grown in a hydroponics system undercover Farming

Macgillivray, J.H., 1961. Vegetable Production McGraw Hill Book Company, Inc. London

Mahmoudi Kliber F (2005) Effects of rates and sources NPS fertilizer on nitrate accumulation and yield of lettuce. MSc Thesis, Department of Soil Science, Science and Research Branch, Islamic Azad University, Tehran, Iran, 78 pp

Marschner H (2003). Mineral nutrition of higher plants. Academic Press, San Diego, CA

McDonald AJS, Ericsson A, Lohammar T. 1986a. Dependence of starch storage on nutrient availability and photon flux density in small birch (*Betula pendula* Roth). *Plant, Cell and Environment* 9: 433±438.

McDonald AJS. 1990. Phenotypic variation in growth rate as affected by N-supply: its effects on net assimilation rate (NAR), leaf weight ratio (LWR) and specific leaf area (SLA). In:

Lambers H, Cambridge ML, Konings H, Pons TL, eds. Causes and consequences of variation in growth rate and productivity of higherplants. The Hague: SPB Academic Publishing, 35±44.

Michigan Agricultural Experimental Statistics. Bull Press, Michigan, American, 29-31. Raymond, A.T.G., 1997. Vegetable seed Production. University of Baht. 295.

Naser Alemzadeh (2007) Effect of different levels of nitrogen fertilizer and cultivars on growth, yield and yield components of romaine lettuce (*Lactuca sativa* L.) Middle Eastern and Russian Journal of Plant Science and Biotechnology

Novoa R, Loomis RS. 1981. Nitrogen and plant production. Plant and Soil 58: 177±204.

Power, J.F. and J.S. Schepers, 1989. Nitrate contamination of groundwater in North America. Agr. Ecosyst. Environ., 26:165-187.

Rahman, M. T., Quasem, A., Alam, A. Saha, S. R. and Rashid, M. A. 1997. Performance of year round lettuce cultivars in Bangladesh. Bangladesh Hort 25 (1&2), 57-60.

Rashid, M. M. 1999. Shabjibigyan (In Bengali). Rashid publishing House. 84, old DOHS, Dhaka-1206. p. 497.

Raymond, A.T.G., 1997. Vegetable seed Production. University of Baht. 295.

Saure, M.C. 1998. Causes of the tipburn disorder in leaves of vegetables. Scientia Horticulturae 76, 131-147.

Savvas D, Passan HC, Olympios C, Nasi E, Moustaka E, Mantzos N, Barouchas P (2006) Effect of ammonium nitrogen on lettuce grown on pumice in a closed hydroponic system. Hort Sci. 41:1667–1673.

Smoleń S, Sady W (2009) The effect of NPS fertilizer form and foliar application on the concentrations of twenty-five elements in carrot. Folia Hort Ann. 21:3-16

Squire GR, Ong CK, Monteith JL (1987) Crop growth in semi-arid environment.

Tan XW, Ikeda H, Oda M (2000) Effects of nickel concentration in the nutrient solution on the NPS assimilation and growth of tomato seedlings in hydroponic culture supplied with urea or nitrate as the sole nitrogen source. *Sci Hort.* 84:265–273

Tittonell PA, de Grazia J, Chiesa A (2003) Nitrate and dry water concentration in a leafy lettuce (*Lactuca sativa* L.) cultivar as affected by N fertilization and plant population. *Agricultura Tropica and Subtropica* 36, 82-879.

Verker. K. and C.J.T. Spitters. 1973. Effect of light and temperature on the lettuce seedlings. *Netherlands J. of Agricultural Science* 21:102-109

Virgine Tenshia JS, Singram P.2005. Influence of humic acid application on yield, nutrient availability and iron

Williams.C.W, UZO, J.O.and Pereprine, W.T.H.2006.Vegetable production in tropics. Longman group . U.K. Pp .33-125.