INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2006/08–5–583–587
http://www.fspublishers.org

Growth and Yield of Sunflower as Affected by Different Salt Affected Soils

A.A. ABD EL-KADER[1], A.A.M. MOHAMEDIN† AND M.K.A. AHMED
Soils and Water use Department and Field Crops Department, National Research Center, El bohoth st., Dokki, Giza, Egypt
†*Soils, Water and Environmental Research Institute, Agriculture Research Center, Giza, Egypt*
[1]Corresponding author's e-mail: aaabdelkader@yahoo.com

ABSTRACT

The quality of soil is a main factor influencing the land use in agriculture and the sustainable development of farming systems. Egypt is one of the countries that have been highly affected by salinity and a large area of agricultural lands is now rated as un-productive as a result of salinity. Field plot study was initiated to determine the effects of both soil quality and soil depth on growth, seed and oil yield of sunflower *(Helianthus annuus* L.) grown under increasing levels of soil salinity. A field plot experiment was conducted in Senores, El-Fayoum governorate, through 12 soil profiles in four plots represented four different soil qualities on the base of saline and alkali soil. Three different profile depths, i.e. 110, 100 and 80 cm were studied during the summer season of 2004 - 2005. Considerable decrease in the growth parameters (plant height, stem diameter, number of leaves, leaf area index & disc diameter) were found in response to both soil depth and soil quality (salinity levels). Seed and oil yield were also reduced by salinity. Salinity decreased micronutrients (N, P & K) content and uptake in leaves of sunflower. Mn, Zn and Fe level was decreased, whereas that of Na and Cl was increased in leaves and seeds of the plants. These changes in macro- and micronutrients under salinity might result from salinity effect on nutrient availability, competitive uptake or partitioning within leaves and seeds. The data revealed that salinity and nutrient interactions reduced crop yield in average by 20% depends upon the salinity level and composition of salts. This points to possibility that sunflower can be successfully used in annual cropping systems as reclaiming crop due to its tolerance to salinity, particularly when fertilization rate is increased.

Key Words: Soil quality; Soil depth; Salinity levels; Sunflower yield

INTRODUCTION

Agricultural land is an important component of environment and the natural landscape. It includes the results of past and present human activity. The soil, as a major subsystem of land, is changing over time as a result of changes in its environment or management. The quality of soil is a main factor influencing the land use in agriculture and the sustainable development of farming systems.

Salinity is one of the major problems that faces the farmers all over the world. More than 25% of irrigated land is saline in Egypt, Iran, Iraq, India, Pakistan and Syria (Choukr-Allah, 1996). In some irrigated areas, salinization is exacerbated by the development of soil sodicity associated with the use of irrigation water containing high concentrations of sodium, carbonate and bicarbonate (Qureshi & Barrett-Lennard, 1998; Barrett-Lennard, 2003). Soil salinity limits crop productivity in irrigated lands. Secondary salinity (i.e. salinity induced by human activity) is a desertification problem of increasing world concern as pressure increases on agricultural land for food production. Secondary salinity affects about 76.6 M ha worldwide (Ghassemi *et al*., 1995). This has been mostly caused by increased seepage (due to irrigation or the removal of deep-rooted vegetation), the development of shallow water-tables and the remobilisation of salt stored in the soil profile to the soil surface. Egypt is one of the countries that have been highly affected by salinity and a large area of agricultural lands is now rated as un-productive as a result of salinity. In Fayoum governorate, vast area of lands becomes infertile and un-suitable for crops productivity, because of soil salinization (Hans & Kevin, 1992). The sunflower (*Helianthus annuus* L.) represents one of the important oil crops in Egypt (Mohamedin *et al*., 2004). There are very few reports about sunflower resistance to salt stress or alkali stress (Liu & Baird, 2003). Sunflower contains high percentage of poly-un-saturated fatty acids and low cholesterol level. Growing sunflower under saline environments will lead to proper management practices soil salinity threatens the permanence of irrigated lands. This field plot study was therefore conducted to determine the effects of both soil quality and soil depth on growth, seeds and oil yields of sunflower grown under increasing levels of soil salinity prevailed at the north of El-Fayoum depression.

MATERIALS AND METHODS

A field experiment was conducted in Senores, El-Fayoum governorate. The area is bounded by Bahr Tandud irrigation canal on western side and Abo-Tarfaia main drain on the eastern side, which facilitates the water dispose into drainage system. The experiment included four plots represented four different soil quality based on saline and alkali soil classifiation (Page *et al*., 1982).

There were three different profile depths, i.e. 110, 100 and 80 cm. The experiment was conducted during the summer season of 2004 - 2005 using sunflower (*Helianthus annuus* L.) Fedok varieties as imported cultivar. The experiment was setup in a complete randomized design with three replicates for each treatment as follows: (1) 110 cm soil depth in normal soil, (2) 110 cm soil depth in saline soil, (3) 110 cm soil depth in saline-alkali soil, (4) 110 cm soil depth in alkali soil, (5) 100 cm soil depth in normal soil, (6) 100 cm soil depth in saline soil, (7) 100 cm soil depth in saline-alkali soil, (8) 100 cm soil depth in alkali soil, (9) 80 cm soil depth in normal soil, (10) 80 cm soil depth in saline soil, (11) 80 cm soil depth in saline-alkali soil and (12) 80 cm soil depth in alkali soil. The area of the plot was 10.5 m^2 (5 ridges, each 3 m length & 0.7 m width) in health 20 cm apart.

The physical and chemical properties of the studied soils were determined according Page *et al*. (1982) and Cottenie *et al*. (1982) and presented in Table I.

Farmyard manure, super phosphate (15.5% P_2O_5), and potassium sulphate (48 – 52% K_2O) were incorporated in to the soil during management practices at the rates of 20 m^3, 30 kg and 24 kg/fed, respectively. Ammonium sulphate (20.5% N) at the rate of 60 kg/fed for the first season and 60 kg/fed for the second one, were applied. Micronutrients were sprayed thrice as chelates at the rate of 100, and 200 g/fed of Mn (EDTA, 13% Mn), Zn (EDTA, 14% Zn) and Fe, respectively.

Representative plant samples of three replicates of each treatment were randomly taken after 90 day of sowing. The following measurements were determined during the two successive seasons.

Sunflower vegetative growth. Plant height (cm) was measured from the cotyledon node to the upper-most height of the plant. Stem diameter, leaf number and leaf area index (cm^2) were measured.

Yield and its components. Seed yield (kg/fed), weight of 1000 seeds (g) were determined. Seed oil % was estimated using sox-let apparatus and petroleum ether as a solvent.

Chemical analysis of leaf and seeds. The method of Page *et al*. (1982) was used to determine both macro and micronutrients. Macronutrients (N, P & K) concentrations were determined as g/100 dry weight and up-take as mg/plant. Micronutrients concentrations were determined as mg/kg dry weight.

Statistical analysis. The results were subjected to analysis of variance (Snedecor & Cochran, 1982). The combined data of both experimental seasons were used for the presnted results and the least significant difference (L. S. D.) at 0.05 level of probability was calculated. Regression analysis was used in order to examine the relation between soil EC and weight of 1000 seed.

RESULTS AND DISCUSSION

Both soil depth and soil quality decreased significantly the growth parameters tested (plant height, stem diameter, number of leaves & leaf area index) as well as yield and its components (weight of 1000 seeds, disc diameter, oil % & yield/fed, Table II). The reduction in the previous parameters increased with decreasing soil depth and salinity, more so with alkali soil. Similar growth reduction has been reported in sunflower in response to salinity (Ibrahim & Abou-Arab, 1997; Delgado & Sanchez, 1997, 1999; Malik *et al*., 1999; Santos *et al*., 1999; El-Kheir *et al.,* 2000). The previous authors suggested that salinization of soils or irrigation water reduces vegetative and reproductive growth and therefore the yield of most cultivated plants. Reduction in growth, yield and its components under salinity stress has been also demonstrated in safflower (Mehmet & Ahmet, 2003).

The obtained data of seed yield of fedok cultivar was significantly reduced by increasing salinity level as shown in Fig. 1, which indicated linear regression between soil EC and relative yield as weight of 1000 seed. Because a 50% reduction in yield was achieved at soil EC of 9.4 dS m^{-1}, it could be concluded that fedok sunflower cultivar is moderately tolerant to soil salinity. Therefore, it can be grown successfully on most agricultural soils, particularly, newly reclaimed soil. These results are in accordance with those obtained by Saha and Gupta (1997) and Francois (1996), who found that sunflower was un-affected by soil salinity up to 5 dS m^{-1} and thus it is considered as moderately tolerance species. Also, Katerji *et al*. (2000) classified sunflower as a tolerant crop on the basis of the estimation of the crop water stress index. Oad *et al*. (2001) recommended that sunflower can be used for saline soils and it should be planted on furrows and water applied at the rate of 50% soil moisture depletion level for maximum water use efficiency and satisfactory sunflower seed yields.

Seed oil content was decreased after salt imposition (Table II), which is consistent with the findings of El-Khair *et al*. (2000) and Flagella *et al*. (2004), who observed significant reduction in seed oil yield with increasing salt level in sunflower grown in saline conditions.

Data presented in Tables III and IV showed that N, P and K were decreased in the plant leaves and seeds in response to both soil depth and Soil quality. For N, the reduction was in the opposite trend as compared with that of P and K, i.e. N increased with soil quality whereas P and K decreased with the same factor. The three (N, P & K) macronutrient concentration reduction pattern reported previously was similar to that obtained for their up-take (mg/plant, on the dry weight basis) (Fig. 2). The decrease in P and K could be interpreted by the effect of the increased level of Na, whereas the effect of Cl on N up-take should be considered. Our interpretation is supported by the finding of Delgado and Sanchez (1997), who indicated that increasing salinity decreased P and K content in both roots and stems

Table I. Some physical and chemical properties of the studied soil
(a) Physical properties

Soil quality	Sand > 200 µ -20µ %	Silt 20 – 2 µ %	Clay ‹2 µ %	Soil texture class	S.P
Normal	24.55	30.46	44.83	Clay	76.53
Saline	18.18	31.05	50.63	Clay	100.53
Saline -alkali	24.21	28.45	47.45	Clay	101.01
Alkali	24.92	30.78	44.31	Clay	89.33

(b) Chemical properties of the soils and irrigation water

Soil quality	pH 1:2.5	E.C Cdm^{-1}	OM %	CaCO3 %	Soluble Cations meq/l				Soluble anions meq/l				ESP
					Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	
Normal	7.9	2.04	0.92	1.58	11.87	6.83	11.01	0.41	--	2.62	6.82	20.63	5.91
Saline	7.7	7.79	2.37	1.66	6.13	9.75	57.23	0.39	--	2.62	38.34	36.31	9.68
Saline alkali	8.17	7.80	0.43	0.67	22.03	15.17	32.22	0.75	--	2.26	34.42	34.10	21.01
Alkali	8.01	3.69	1.51	0.93	3.38	3.87	36.31	0.35	--	3.04	16.79	16.68	19.51
Irrig. Water	8.60	3.49	--	--	9.15	4.92	20.45	0.36	--	20.38	4.41	10.08	--

Table II. Effect of soil quality (salinity level) on growth and yield characters. The data are the mean of the two studied seasons

Treatment Soil depth	Soil Quality	Plant height (cm)	Stem diameter (mm)	Leaf number	Leaf area index (cm^2)	Weight of 1000 seeds	Oil % in seeds	Disc diameter (cm)	Yield kg/fed.
110	Normal	190.33	21.67	51	117.49	99.10	27.99	15.0	1482.6
	Saline	158.67	17.67	44	106.83	83.17	26.47	12.7	1324.1
	Saline alkali	145.00	16.00	36	69.42	81.33	24.52	9.8	1256.6
	Alkali	131.33	11.33	30	45.92	58.33	23.23	6.0	1179.4
100	Normal	188.33	20.67	50	103.17	78.20	27.61	14.6	1433.8
	Saline	154.67	17.00	42	89.50	64.50	25.77	11.9	1321.2
	Saline alkali	142.67	15.00	34	62.02	53.13	23.99	8.7	1262.6
	Alkali	129.33	9.67	28	45.80	47.47	22.96	5.7	1201.7
80	Normal	187.00	20.00	49	106.36	106.80	26.61	13.8	1416.9
	Saline	151.00	16.67	41	80.04	79.17	25.08	11.0	1353.8
	Saline alkali	142.00	14.00	33	52.56	65.90	23.58	7.4	1281.1
	Alkali	127.00	9.33	26	44.67	42.90	22.23	5.6	1168.5
LSD at 0.05 level		3.52	1.42	2.16	7.92	6.48	0.60	0.30	75.35

Table III. Effect of soil quality (salinity level) on concentration of macro and micronutrients in leaves. The data are mean of the two studied seasons

Treatment		Concentration of macro- nutrients in leaves				Concentration of micro -nutrients in leaves			
Soil depth	Soil quality	N %	P %	K %	Na %	Cl %	Fe ppm	Zn ppm	Mn ppm
110	Normal	3.10	0.67	3.14	1.02	0.38	209	73	82
	Saline	2.49	0.59	2.88	2.50	4.46	204	62	66
	Saline alkali	2.73	0.40	2.57	3.30	3.68	172	41	37
	alkali	2.88	0.27	2.16	3.94	2.84	138	22	34
100	Normal	2.99	0.63	3.06	1.68	0.45	206	72	73
	Saline	2.43	0.54	2.76	2.81	4.78	190	53	61
	Saline alkali	2.66	0.33	2.37	3.89	4.13	166	34	36
	alkali	2.79	0.24	2.11	4.27	3.25	122	20	23
80	Normal	2.80	0.59	3.02	1.68	0.80	194	42	72
	Saline	2.39	0.48	2.58	3.46	5.08	177	51	58
	Saline alkali	2.47	0.28	2.35	4.37	4.24	153	32	31
	alkali	2.57	0.22	2.07	4.72	3.01	104	15	18
LSD at 0.05		0.13	0.04	0.16	0.04	0.13	13.7	9.09	5.93

%: g/100 g dry weight
ppm: mg/ kg dry weight

of sunflower seedlings. Similarly, Santos *et al*. (1999) observed that salinity decreased NO_3, P and K content in the whole sunflower plants. Moreover, Decheng and Sheng (2005) showed that the physiological responses of sunflower are not only closely correlated with salinity (the total concentration of stress salt) but also with the pH (i.e. alkalinity).

Macro and micronutrient concentrations were significantly affected in sunflower leaves and seeds in response to both soil depth and quality (Tables III & IV). In the leaves, the increase in Na and Cl was decreased with soil depth (Table III). We propose that this effect was due to soil

Table IV. Effect of soil quality (salinity level) on concentration of macro- and micronutrients in seeds. The data are mean of the two studied seasons.

Treatment		Macro nutrients %			Micro nutrients Ppm		
Soil depth	Soil quality	N	P	K	Fe	Zn	Mn
110	Normal	6.00	0.97	6.74	738	156	166
	Saline	5.11	0.87	6.07	673	140	147
	Saline alkali	4.55	0.79	5.51	497	99	127
	alkali	3.80	0.61	4.82	397	79	104
100	Normal	5.80	0.95	6.57	708	150	162
	Saline	4.99	0.84	5.75	609	133	143
	Saline alkali	4.25	0.74	5.24	437	95	121
	alkali	3.35	0.57	4.19	374	79	84
80	Normal	5.55	0.90	6.12	680	143	156
	Saline	4.86	0.83	5.58	578	126	139
	Saline alkali	3.89	0.71	4.81	412	85	116
	alkali	3.02	0.51	4.03	347	69	74
LSD at 0.05 level		0.24	0.02	0.32	26.4	8.74	7.89

%: g/100 g dry weight
ppm: mg/ kg dry weight

Fig. 1. Relative seed yield of sunflower grown at sanores in 2004-2005 as function of increasing salinity

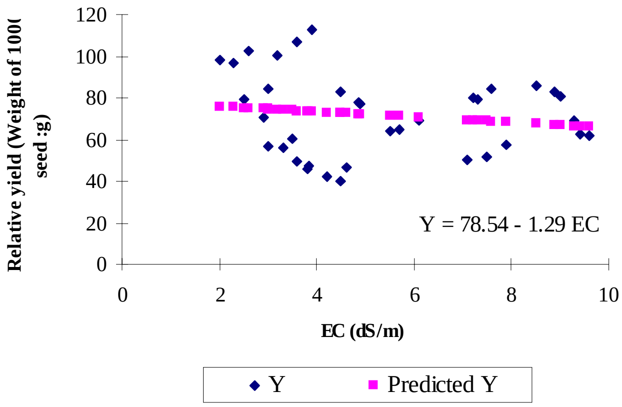
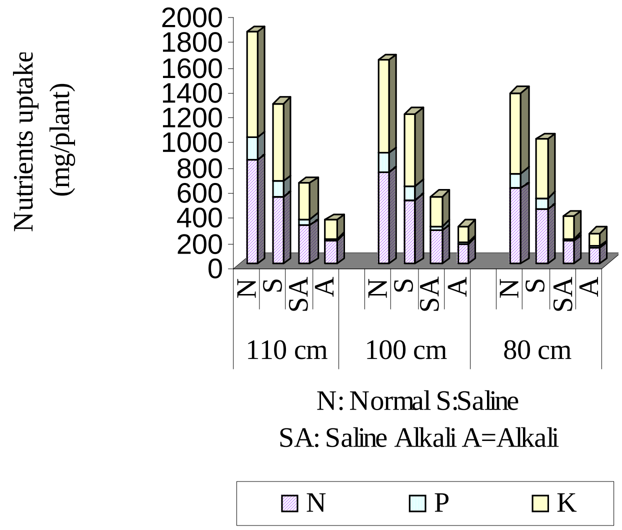


Fig. 2. Effect of soil quality (saline level) and soil depth on macronutrients uptake of sunflower leaves



physical and chemical properties changes with soil depth. Salinity-induced increase in Na and Cl has been previously reported in sunflower (Jose *et al*., 2005).

The level of Fe, Zn and Mn in the sunflower leaves and seeds was decreased consistently with soil depth and quality (Tables III & IV). This reduction might be due to high soil pH than 7.5. Salinity-induced decrease in Fe, Zn and Mn level of sunflower leaves was similarly reported by Sanchez and Delgado (1996), Delgado and Sanchez (1998) and Santos *et al.* (1999) and the decrease in these elements in sunflower seeds was also found by Sepeh *et al.* (2002) and Moamedin *et al.* (2004).

CONCLUSION

Sunflower fodek cultivar growth adversely affected by soil depth and soil quality (saline, saline alkali & alkali soils), which also induced nutrients interactions. These interactions may result from the effect of salinity on nutrient availability in soil, competitive up-take, transport or partitioning within the plant. Salinity directly affect nutrient up-take, such as Na reduced K up-take and Cl reduced N up-take as well as internal nutrient requirement. The data revealed that salinity and nutrient interactions were reduced crop yield in average by 20% depends upon the salinity level and composition of salts. Results indicated that sunflower can be used successfully in annual cropping systems as reclaiming crop due to its tolerance to salinity, in the studied area with particularly increasing fertilization rates to reduce salinity effects.

REFERENCES

Barrett-lennard, E.G., 2003. The interaction between water-logging and salinity in higher plants: causes, consequences and implications. *Pl. Soil*, 253: 35–54

Cottenie, A., M. Verloo, L. Kekens, G. Velgh and R. Camberlynck, 1982. *Chemical Analysis of Plants and Soils*, Pp: pp 15–9. Laboratory Agro-chemistry State University Ghent

Choukr-allah, R., 1996. The potential of halophytes in the development and rehabilitation of arid and semi-arid zones. *In*: Choukr-allah, R., C.V. Malcolm and A. Hamdy, (eds.) *Halophytes and Bio-saline Agriculture,* Pp: 3–13. Marcel Dekker, New York

Decheng, S. and Y. Sheng, 2005. Effect of various salt–alkaline mixed stress conditions on sunflower seedlings and analysis of their stress factors. *Environ. Exp. Bot*., 54: 8–21

Delgado, I.C. and R.A.J. Sanchez, 1997. Physiological response of sunflower seedlings to salinity and potassium supply. *Comm. Soil Sci. Pl. Anal*., 30: 773–83

Delgado, I.C. and R.A.J. Sanchez, 1998. Nutritional response of sunflowers (*Helianthus annuus* L.) to Fe application under saline conditions. *Phyton (Buenos Aires)*, 62: 79–86

Delgado, I.C. and R.A.J. Sanchez, 1999. Initial shoot development of sunflower under special saline conditions. *Phyton (Buenos Aires)*, 65: 1–2; 1–5

El-Kheir, M.S.A.A., S.A. Kandil and H.A. El-Zeiny, 2000. Growth, yield and some physiological processes of sunflower plants as affected by paclobutrazol treatments under salt stress conditions. *Egypt J. Agron.*, 22: 107–24

Flagella, Z., M.M. Giuliani, T. Rotunno, R. Di Caterina and A. De Caro, 2004. Effect of saline water on oil yield and quality of a high oleic sunflower (*Helianthus annuus* L.) hybrid. *European J. Agron*., 21: 267–72

Francois, L.E., 1996. Salinity effects on four sunflower hybrids. *Agron. J*., 88: 215–9

Ghassemi, F., A.J. Jakeman and H.A. Nix, 1995. *Salinisation of Land and Water Resources: Human Causes, Extent, Management and Case Studies,* P: 526. University of New South Wales Press, Sydney

Hans, C.J. and W.J. Kevin, 1992. *Environmental Profile Fayoum Governorate*. Euroconsult/Darwish Conts. Eng., Ershem, The Netherlands

Ibrahim, M.E. and A. Abou-Arab, 1997. Soil salinity effects on growth, yield and seeds quality of Sunflower. *Proceeding of International Symposium of Salt Affected Soils*, Pp: 520–6

Jose, M.F., A.M. Roldan, C. Sanchez, G. Alexandre and M. Benlloch, 2005. K^+ starvation increases water uptake in whole sunflower plants. *Pl. Sci.*, 168: 823–9

Katerji, N., J.W. Van Hoorn, A. Hamdy and M. Mastrorilli, 2000. Salt tolerance classification of crops according to soil salinity and to water stress day index. *Agric. Water Manag*., 43: 99–109

Liu, X. and W.V. Baird, 2003. Differential expression of genes regulated in response to drought or salinity stress in sunflower. *Crop Sci*., 43: 678–87

Malik, R.S., A.P. Gupta, S. Haneklaus and N. El-Bassam, 1999. Role of phosphorus (^{32}P) in inducing salt tolerance in sunflower. *Landbauforschung Volkenrode*, 49: 169–76

Mehmet, D.K. and Z.R. Ahmet, 2003. Effects of Different Soil Salinity Levels on Germination and Seedling Growth of Safflower (Carthamus tinctorius L.). *Turk J. Agric*., 27: 221–7

Mohamedin, A.A.M., A.S.A. Osman, N.M. Badr and K.I. Kotb, 2004. Productivity of sunflower yield and yield composition under different drainage systems at Egyptian salt affected soils. *Egypt J. Appl. Sci*., 19: 749–63

Oad, F.C., A. Soomro, N.L. Oad, Z.A. Abro, M.A. Issani and A.W. Gandahi, 2001. Yield and water use efficiency of sunflower crop under moisture depletions and bed shapes in saline soil. *J. Biol. Sci*., 1: 361–2

Qureshi, R.H. and E.G. Barrett-lennard, 1998. *Saline Agriculture for Irrigated Land in Pakistan: A Handbook*, P: 142. Monograph No. 50, Australian Centre for International Agricultural Research, Canberra

Page, A.L., R.H. Miller and D.R. Keeney, 1982. *Method of Soil Analysis. Chemical and Microbiological Properties*, Agronomy 9, Part 2, A.S.A, SSSA, Madison, Wisconsin, USA

Saha, K. and K. Gupta, 1997. Effect of NaCl-salinity on ethylene production and metabolism in sunflower seedlings. *Indian J. of Pl. Physiol*., 2: 127–30

Sanchez, R.A.J. and I.C. Delgado, 1996. Mineral nutrient transport by sunflower seedlings grown under saline conditions (NaCl). *J. Pl. Nutr.*, 19: 1463–75

Santos-dos, C.V., G. Caldeira and C.L.V. Dos-Santos, 1999. Comparative responses of *Helianthus annuus* plants and calli exposed to NaCl. I-Growth rate and osmotic regulation in intact plants and calli. *J. Pl. Physiol.*, 155: 769–77

Sepeh, E., M.J. Malakouti and M.H. Rasouli, 2002. *Effect of K, Mg, S and Micronutrients on the Yield and Quality of Sunflower in Iran,* P: 2260. 17th WCSS, 14–21 August 2002, Thailand

Snedecor, M. and J. Cochran, 1982. *Statistical Methodes, 7th ed, 2nd* printing, P: 507. Iowa State University Press, Iowa, USA

(Received 18 May 2006; Accepted 16 July 2006)