GROWTH AND YIELD QUALITY OF SWEET CORN, AS INFLUENCED BY NITROGEN FERTILIZATION LEVELS IN SULAIMANI REGION

[1]A. A. Mohammed [2]Z. M. Majid [1] S. A. S.Kasnazany [2]S. J. Salih
Assist. Prof. Researcher. Lecturer Researcher
[2]Sh. B. Mustafa [2] O. A.Salih
Researchert Resaercvher
[1]College of Agricultural Sciences, Sulaimani University, Sulaimani, KRG
[2]Center of Agricultural Research of Sulaimani. Sulaimani, KRG
Corresponding author: sdiq.sdiq@univsul.edu.iq

ABSTRACT

Four sweet corn varieties (*Zea mays ssp. Saccharata*), Gold Rush (v_1) and Chocolate (v_2), originated from Japan and 001(v_3), and 003 (V_4) are France originated, were cultivated under the effect of three different levels of nitrogen fertilization (120, 170and 230) kg ha^{-1}as (N1, N2, and N3) in two different locations in Sulaimani region (Bakrajo and Kanipanka), Iraqi Kurdistan Region in order to investigate the effects of some environmental and climatic factors on growth performance and yield quality of sweet corn varieties in the open field. By using a factorial experiment within RCBD with three replications, the results revealed that indicated to significant differences in the response of four varieties under the effect of the Nitrogen fertilization levels in both locations in the criteria concerned with sweetness such as TS%,TSS%, and NSS%, while the significant effect of Nitrogen levels N2 and N3 were revealed in quality related criteria TS% and TSS% in both locations.

Key words: sweet corn, environmental and climatic conditions, sweetness, varieties responses.

تأثير مستويات السماد النايتروجيني لنوعية النمو والحاصل في الذرة السكرية في منطقة السليمانية

أرام عباس محمد[1] زنا محمد مجيد[2] صديق علي صديق[1] سانا جمال صالح [2]
شتروي بكر مصطفى[2] عمر علي صالح[2]
1–كلية الزراعة – جامعة السليمانية
2– مركز البحوث الزراعية في السليمانية

المستخلص

زرعت أربعة أصناف من الذرة الحلوة (*Zea mays ssp. Saccharata*)،Gold Rush (v1)وChocolate (v2) من فرنسا و001(v3) و003(v4) من اليابان، في الموقعين المختلفين في منطقة السليمانية (بكرجو وكانى بانكة) تحت تأثيرثلاثة مستويات مختلفة من التسميد النيتروجيني (120،170و230) كغم/هكتار بأستعمال التجربة العاملية في تصميم القطاعات الكاملة المعشاة وبثلاث مكررات، أظهرت النتائج تفوق معنوي في استجابة أربعة أصناف المذكورة تحت تأثير مستويات التسميد النيتروجيني في كلا الموقعين لصفات المتعلقة بالحلاوة مثل TS٪ وTSS٪ و NSS٪، في حين أن التأثير الكبير لمستويات النيتروجين أظهرت تحت مستويات النيتروجين(170و230) كغم/هكتار في TSS٪ وTS٪ لكلا الموقعين.

الكلمات المفتاحية: الذرة الحلوة، والظروف البيئية والمناخية،حلاوة،استجابة الأصناف.

***Received:25/10/2016, Accepted:4/1/2017**

INTRODUCTION

Sweet corn (*Zea mays* ssp. *saccharata*) is an important vegetable which produced kernels consisting mostly sugar rather than starch, it became more valued in recent years, it is consumed as fresh, frozen or conserved and also used in the salads. However, the sugar in the kernels rapidly converts to starch after its prime harvest stage; sweet corn can be harvestedwhen it reaches the milk stage, while kernel moisture is at approximately 72 to 76 percent, "When sweet corn is ripe, waiting is not an option (22). There are three types of sweet corn, normal, sugar enhanced and super sweet, each one contains a different level of sucrose, changing the flavour and texture of the corn. Sweeter varieties will stay sweeter for longer after harvest. Components of sweet corn include 5 to 6% sugar, 10 to 11% starch, 3% water-soluble polysaccharides, and 70% water; it also contains moderate levels of protein, vitamin A (yellow varieties) and potassium, (16 and18). Fertilization with nitrogen will adjust the balance between yield and quality; include application rate and fertilizer materials, placement, and timing (9).Results of previous studies indicated in effect, of nutrition levels which caused yield, and also affected the chemical composition and quality of the marketable ear and it is genotype-dependent. Higher fresh ear yield of sweet corn under the effect of middle nitrogen treatment in comparisonto other two treatments, as well as the soluble sugar content and protein content of middle nitrogen level was the highest among different nitrogen levels.The application of 200 kg N/ha for sweet corn, which assumed 50% availability of the total N(20). Sweet corn kernels and ear leaves were digested and analysed for 12 macro- and micronutrients showing significant variation in response of sweet corn varieties and other tested crops (21). Application of 80 kg N/ha produced a significantly highest number of prime cobs (62,328 ha), green-cob yield (9.80 tonnes/ha), length (17.5 cm) and girth (16.7 cm) of cobs, green-forage yield (17.35 t/ha), (19, 10, 11and 22). According to the results of other researchers (12), Sweet corn means corn with sweetness that the total soluble solids content not to be less than 9 degrees Brix. Sweet corn shall be whole with or without husk and the kernel shall be on the cob. Results of variation in sowing time, the sweetness of the green cob i.e., TSS% (Brix) value varied significantly due to different sowing dates with different climatic conditions(15). The quality of fresh market sweet corn is judged by its fresh, uniform appearance, uniform and well filled rows; it is consumed in the immature stage of the crop. The taste of sweet corn kernels is 25-30% sweeter than normal corn. At optimum market maturity, sweet corn will contain 5 to 6% sugar, 10 to 11% starch, 3% water-soluble polysaccharides, and 70% water (18). Although sweet corn prefers full sun and fertile, well drained soil for maximum yield, but till now it has been cultivated inside the plastic house under semi-control conditions in our region, that may related to the high temperature in the growth season of the this crop which effect its sweetness, so that this present study is considered as the first attempt in Sulaimani region for cultivation in the open field, so in this study, we investigate the effects of environmental conditions of two different locations on growth performance and yield and quality of four sweet corn varieties that treated with three levels of nitrogen fertilizations.

MATERIALS AND METHODS

Four different varieties of sweet corn (*Zea mays spp.saccharata*) Gold Rush, Chocolate, originated from Japan and 001, and 003 which are France originated, were cultivated at the experimental fields of Agricultural Research Center of Sulaimani, in 2015 at two different locations Bakrajo and Kanipanka. Two different field experiments were implemented by factorial experiment within RCBD using three replications. The sowing date was on

11/4/2015 and 20/4/2015 at Bakrajo and Kanipanka, respectively. The 4th different varieties were considered as treatment no.1 and three different nitrogen levels (120, 170and230kg.ha^{-1}) as the second treatment (N_1, N_2, and N_3). The nitrogen fertilizer was used by two different application times, the 1st part was applied at sowing while the 2nd part in the growth stage(the period between 4 leaf stage and tasseling) was applied (4,8). The cultivation area was isolated over 100 m from other experimental fields of corn crop (7). The data were analysed by Analysis of variance and the means compared using Duncan Multiple Range atthe 5% level. Some vegetative and reproductive criteria were studied, including (no. of days required to 50% tasseling, no. of days required to 50% silking, plant fresh weight, plant dry weight, Leaf Area Index measured by Elsahookie method (5), ear length and freshyieldKg.ha^{-1}), as well as chemical criteria at harvesting such as (Moisture content%, TS%, TSS% and NSS%), the harvesting date was adjusted 20 days post silking, at the early dough stage. Chemical criteria related to the sweet corn quality were tested at labs. Of FAS-Univ. of Sulaimani as following:

1-The moisture content (M %) was determined according to standard methods (2).

2-Total solids (TS %): Total solids have been determined according to (1), calculated by the following formula: TS%= 100 - % moisture content (M %).

3-Total Soluble Solids (TSS %): Hand Refractometer (LCD digital model) was used to determine TSS%. A drop of the fruit extract was placed on the prism of digital Refractometer and the total soluble solids values were read in °Brix (1).

4-Non soluble solids (NSS %) = TS% - TSS%.

5-Ear length (cm) calculated by digital vernier calipers.

RESULTS AND DISCUSSION

No. of days required to 50% tasseling and 50% silking:

At both locations, there was not significant differences in number of days required to 50% tasseling and to 50% silking, among sweet corn varieties and effect of nitrogen levels, but the growth period to 50% tasseling was between (60.000 to 63.556) days recorded by varieties (V_2 and V_3) respectively, and the period to 50% silking was between (73.000 to 74.333) days showed by ($V_4$and V_3), respectively in Bakrajo (Tables 1 and 2). at periods to 50% tasseling and 50% silking in Kanipanka were much shorter than Bakrajo in which number of required days to 50% tasseling was between (52.111 and 56.333)days recorded by (V_1 and V_3),respectively, while the length of the period to 50% silking was between (67.222 to 69.444) days shows by (V_4 and V_2), respectively (Tables 3 and 4), Indicating to a great effect of climatic conditions of the two locations on growth performance of sweet corn varieties. The results are also similar to those obtained by other researchers (14, 16). Effect of nitrogen levels showed no significant differences at both locations as well as the lowest variations, especially in the number of days to 50% silking at Bakrajo which was between (73.167 to 74.417)days, but shorter period for these two stages was noticed at Kanipanka (52.750 to 54.833)days and (68.166 to 68.833) days.

Plant fresh and plant dry weights:

Effect of sweet corn varieties and nitrogen levels on plant fresh weight which represents plant biological yield showed no significant differences in both locations, but there were variations among varieties. At Bakrajo, the plant fresh weight ranged from (460.444 to 606.778 g) recorded by (V_1 and V_4), respectively, while at Kanipanka, it was ranged from (908.888 to 1186.556 g) shown by (V_4 and V_3),respectively, that directly affected plant dry weight which in Kanipanka showed higher value between (115.555 and 138.555 g) by (V_4 and V_1),respectively in compare to lower range in Bakrajo (84.889

and 110.778 g)that shown by varieties(V_1 and V_3),respectively (4). Higher fresh and dry weights of plant in Kanipanka reveal the positive response of sweet corn varieties to higher temperature and humidity of Kanipanka during vegetative growth in April and May. Levels of nitrogen were non significantly affectedon both plant fresh weight and plant dry weight at both locations, although highest dry weight was recorded under the effect of level N_3 at both locations, results were in agreement with (21).

Leaf Area Index (LAI):

Tables 1 and 2, reveal variations in leaf area index among four sweet corn varieties at both locations, in which the higher means of LAI of all varieties at Kanipanka in compare to Bakrajo is considered as clear indication to larger area of photosynthesis that led increase in gross photosynthesis and greater biomass and better growth performance of all varieties in this location if the respiration means will not rise under the effect of higher day-night temperature, because temperature is the most important among all environmental factors that influence the rate of plant development(17). The value of LAI in Bakrajo was between (1.442 to 1.722) by varieties (V_1 and V_3) respectively, while higher value at Kanipanka was ranged between (2.583 to 3.268) by varieties (V_1 and V_2) respectively, differences in LAI between genotypes were reported previously by researchers such as (3). Effect of nitrogen levels on LAI was no influenced significantly at both locations with higher value at Kanipanka which was between (2.719 to 2.953)by the effect of N_3 and N_2 respectively while at Bakrajo was between (1.308 to 1.558) for N_3 and N_1 respectively.

Moisture content, TS%, TSS%, NSS%, and Ear Length:

Moisture content is an important character for marketing, according to the data shows in theTables 1 and 2, the M% of harvested ears was between (59.9% to 65.9%)recorded for (V_3 and V_1) at Bakrajo, while higher moisture content was recorded at Kanipanka(68.137% to 73.080%) for (V_1 and V_4)respectively, with significant differences among sweet corn varieties, in which V_4 exceeded others by 73.080% at this location, the M% in Kanipanka was in accordance to standard levels(18). There were significant differences among sweet corn varieties in studied criteria TS%, TSS%, in both locations, while significant differences of NSS% was at Bakrajo only. As showsinTables 1 and 2, TS% recorded by V_3(40.152%)was exceeded other varieties at Bakrajo,while at Kanipanka the superiority was back to V_1 by (31.418%), relatingto TSS% , the exceeding was gained by V_1 at both locations by (21.600% and 18.105%) respectively, but V_2 exceeded significantly in NSS% in compare to other varieties in Bakrajo by (24.265%) and minimum value was shown by V_1 which was (11.208%), the resultsof studied criteria TS%, TSS% and NSS% were greater in Bakrajo than Kanipanka, that may related to higher moisture content of sweet corn kernels(68.137% to 73.080%) in Kanipanka. There were significant differences of effect of levels of nitrogen on TSS% and NSS% at Kanipanka, in which the highest effect shows by N_1 exceeding other levels by 17.600%, while N_3 was with the minimum effect recording (14.158%), but the superiority of level N_3 was in NSS% criteria by (15.130%) and minimum value of NSS% was recorded under the effect of N_1 which was (11.449%). Sweet corn size is determined either by the length of the cob with or without husk, as showsin Tables 1 and 2, the length of ear of four sweet corn varieties at Bakrajo was between (20.566 to 22 033 cm) produced by (V_1 and V_3) respectively, but under the effect of nitrogen levels, the range was between (20.050 to 22.169 cm) shown by (N_3 and N_2)levels respectively, while this range at Kanipanka was between (20.633 to 23.688 cm) registered by (V_4 and V_3)respectively and between (21.150 to 21.883 cm) under the effect of (N_3 and N_1) levels, ear

products of four sweet corn varieties were classified as size number[1]according to(12) classification of length of sweet corn ear with husk (8).

Fresh yield

Tables 1 and 2 indicate to significant differences among all the varieties in both locations, means of fresh yield of all varieties were between 9887.500 to 13027.500 kg.ha^{-1} by varieties V_3 and V_1 respectively at Bakrajo which was lower than at Kanipanka that ranged between 14802.500 to 16452.500kg.ha^{-1} by varieties V_3 and V_4 respectively. Effect of nitrogen levels on fresh yield was not significant at both locations, results agree withthe results of other Researchers (8,10,13, 15,21).

The Interactions

Tables 5, 6, 7 and 8 reveal the effect of interactions between four sweet corn varieties and three different nitrogen levels on the studied criteria at both locations. There were significant differences of effect of interactions between the two treatments in some studied criteria at Bakrajo. The interaction (V_2N_3), exceeded other interactions in TS% and NSS% by (45.206 and 27.906%), respectively, while the interactions (V_1N_3 and V_3N_2) showed

Table (1). Effect of sweet corn varieties and nitrogen levels on vegetative characters inBakrajo

Treatments	No. of days 50% Tasseling	No. of days 50% Silking	Plant fresh Wt.(g)	Plant Dry Wt. (g)	LAI
V1	62.667a	74.111a	460.444a	84.889a	1.442a
V2	60.000a	73.667a	516.111a	93.222a	1.722a
V3	63.556a	74.333a	555.667a	110.778a	1.555a
V4	62.444a	73.000a	606.778a	85.667a	1.562a
N1	61.000a	73.167a	542.417b	72.667a	1.552a
N2	61.333a	73.750a	537.250a	102.750a	1.430a
N3	64.167a	74.417a	524.583a	105.500a	1.308a

Table (2). Effect of sweet corn varieties and nitrogen levels on some quality related characters in Bakrajo

Treatments	M%	TS%	TSS%	NSS%	Ear Length (cm)	Ear Fresh Yield (Kg.ha^{-1})
V1	65.880a	32.808b	21.600a	11.208b	20.566a	13027.500a
V2	59.968a	40.032a	15.766b	24.265a	21.211a	10277.500a
V3	59.847a	40.152a	19.466ab	20.686ab	22.033a	9887.500a
V4	61.986a	38.013ab	18.533ab	19.480ab	20.836a	11195.000a
N1	61.343a	38.656a	21.108a	17.548a	21.266a	10832.500a
N2	60.278a	39.721a	18.625a	21.096a	22.169a	11062.500a
N3	66.790a	33.021b	17.791a	17.084a	20.050a	11395.500a

Table (3). Effect of sweet corn varieties and nitrogen levels on vegetative characters in Kanipanka

Treatments	No. of days 50% Tasseling	No. of days 50% Silking	Plant fresh Wt.(g)	Plant Dry Wt. (g)	LAI
V1	52.111a	68.777a	942.778a	138.555a	3.268a
V2	54.555a	69.444a	1186.667a	137.888a	2.583a
V3	56.333a	68.777a	1005.556a	124.222a	2.683a
V4	53.333a	67.22a	908.888a	115.555a	2.759a
N1	54.833a	68.666a	955.000a	115.833a	2.783a
N2	54.666a	68.833a	967.000a	125.083a	2.953a
N3	52.750a	68.166a	1110.417a	146.250a	2.719a

The minimum value of these two criteria that related to quality recording (32.270 and 13.183%),respectively, but the interactions (V_3N_2 and V_1N_3) showed superiority in criteria TSS% and fresh yield by (25.800 and 14667.500 kg.ha^{-1}),respectively, and the minimum percentage of the TSS% was recorded by (V_2N_2)interaction which was (13.200%), while the lowest fresh yield was

shown by the interaction (V_3N_1) yielding 8250 kg. ha^{-1}.

Table (4). Effect of sweet corn varieties and nitrogen levels on some quality related characters in Kanipanka

Treatments	M%	TS%	TSS%	NSS%	Ear Length (cm)	Ear Fresh Yield ($Kg.ha^{-1}$)
V1	68.137b	31.418a	18.105a	13.312a	20.644a	16415.000a
V2	70.486ab	29.531ab	16.170ab	13.35a	21.266a	16137.500a
V3	71.366ab	28.633ab	16.122ab	12.511a	23.688a	14802.500a
V4	73.080a	26.920b	14.166b	12.753a	20.633a	16452.500a
N1	70.950a	29.049a	17.600a	11.449b	21.883a	14812.500a
N2	70.627a	29.038a	16.970ab	12.367ab	21.641a	16515.000a
N3	70.711a	29.289a	14.158b	15.130a	21.150a	16527.500a

Table (5).Effect of Interaction between sweet corn varieties and levels of nitrogen on vegetative characters inBakrajo

VxN	No. of days 50% Tasseling	No. of days 50% Silking	Plant fresh Wt.(g)	Plant Dry Wt. (g)	LAI
V1N1	61.333a	73.000a	449.338a	81.333a	1.620a
V1N2	61.333a	74.667a	538.000a	84.333a	1.393a
V1N3	65.333a	74. 667a	394.000a	89.000a	1.321a
V2N1	57.333a	73. 667a	516.000a	86.667a	1.411a
V2N2	57.333a	74. 333a	483.000a	94.333a	1.150a
V2N3	65.333a	73. 000a	549.333a	98.667a	1.700a
V3N1	64.667a	73. 000a	544.000a	67.333a	1.700a
V3N2	65.333a	74. 667a	556.333a	133.333a	1.542a
V3N3	60.667a	75. 333a	566.667a	131.667a	1.430a
V4N1	60.667a	73. 000a	660.333a	55.333a	1.485a
V4N2	61.333a	71. 333a	571.667a	99.000a	1.660a
V4N3	65.333a	74. 667a	588.333a	102.667a	1.542a

At Kanipanka, the effect of the interactions between the two treatments did not reach the significantdifferences except on the criteria TSS%, in which the superiority was to V_2N_1 by (21.500%) and the lowest value (11.433%) was shown by the interaction (V_2N_3). There were differences in response of four sweet corn varieties to the three nitrogen levels in the two locations, there were positive responses to nitrogen levels N_2 and N_3 in Bakrajo, as shown in (V_2N_3, V_3N_2 and V_1N_3), however, at Kanipanka, the situation was not similar which may be related to higher fertility of Kanipanka soil and climatic conditions (6).

Table (6). Effect of Interaction between sweet corn varieties and levels of nitrogen on some quality related characters and ear fresh yield in Bakrajo

VxN	M%	TS%	TSS%	NSS%	Ear Length (cm)	Ear Fresh Yield ($Kg.ha^{-1}$)
V1N1	65.390a	32.610b	25.566ab	18.044ab	23.366a	13082.500ab
V1N2	60.453a	39.546a	21.366abc	18.180ab	19.600a	11332.500ab
V1N3	66.396a	32.270b	17.866abc	20.770ab	18.733a	14667.500a
V2N1	64.706a	35.293ab	16.800abc	18.493ab	22.266a	10332.500ab
V2N2	60.406a	39.593a	13.200c	26.393a	21.933a	11250.000ab
V2N3	54.793a	45.206a	17.300abc	27.906a	19.433a	9250.000ab
V3N1	57.746a	42.253a	18.133abc	24.120a	20.833a	8250.000b
V3N2	61.016a	38.983a	25.800a	13.183b	23.733a	11000.000ab
V3N3	60.780a	39.220a	14.466abc	24.753a	21.533a	10415.000ab
V4N1	66.530a	33.470ab	19.933abc	13.536b	18.600a	11665.000ab
V4N2	59.236a	40.763a	14.133bc	26.630a	23.410a	10665.000ab
V4N3	60.193a	39.808a	21.533abc	18.273ab	20.500a	11250.000ab

Table (7). Effect of Interaction between sweet corn varieties and levels of nitrogen on vegetative characters in Kanipanka

VxN	No. of days 50% Tasseling	No. of days 50% Silking	Plant fresh Wt.(g)	Plant Dry Wt. (g)	LAI
V1N1	57.000a	67.000a	930.000a	142.333a	3.176a
V1N2	54.666a	69.333a	940.000a	127.333a	3.371a
V1N3	44.666a	70.000a	958.333a	146.000a	3.259a
V2N1	56.333a	70.000a	1323.333a	137.666a	2.501a
V2N2	52.333a	68.666a	1113.333a	118.000a	2.525a
V2N3	55.000a	69.666a	1123.333a	158.000a	2.725a
V3N1	54.333a	69.333a	823.333a	102.333a	2.675a
V3N2	57.333a	69.000a	996.666a	131.333a	2.854a
V3N3	57.333a	68.000a	1196.666a	139.000a	2.525a
V4N1	51.666a	68.333a	743.333a	81.000a	2.802a
V4N2	54.333a	68.333a	820.000a	123.666a	3.094a
V4N3	54.000a	65.000a	1163.333a	142.000a	2.404a

Table (8). Effect of Interaction between sweet corn varieties and levels of nitrogen on some quality related characters and ear fresh yield inKanipanka

VxN	M%	TS%	TSS%	NSS%	Ear Length (cm)	Ear Fresh Yield (Kg.ha^{-1})
V1N1	69.973a	30.026a	20.266a	9.760a	21.666a	16950.000a
V1N2	67.081a	31.585a	18.350ab	13.235a	20.300a	16825.000a
V1N3	67.356a	32.643a	15.700ab	16.943a	19.968a	15475.000a
V2N1	67.196a	32.803a	21.500a	11.303a	23.533a	14965.000a
V2N2	73.390a	26.610a	15.600ab	11.010a	21.266a	16365.000a
V2N3	70.820a	29.180a	11.433b	17.746a	19.000a	17082.500a
V3N1	72.576a	27.423a	14.066b	13.356a	23.000a	12640.000a
V3N2	68.510a	31.490a	18.566ab	12.923a	23.500a	17307.500a
V3N3	73.013a	26.986a	15.733ab	11.253a	24.566a	14457.500a
V4N1	70.056a	28.944a	14.566ab	13.376a	19.333a	14690.000a
V4N2	73.530a	26.470a	14.166ab	12.303a	21.500a	15565.000a
V4N3	71.653a	28.346a	13.766ab	14.580a	21.066a	19100.000a

REFERENCES

1.A.O.A.C.1990.Official Method of Analysis of Association of Agriculture Chemists, 15th ed., AOAC, Washington, D. C., U. S. A. pp:363

2.ASAE Standards, 43rd ed.1996. S352.2.Moisture Measurement Ungrounded Grain and Seeds. St. Joseph, Mich.: ASAE. pp:497

3.Daughtry, C. S. T. and S. E., Hollinger. 1984. Costs of Measuring Leaf Area Index of Corn. Purdue University. Purdue University LARS Technical Reports. pp: 27. *http://docs.lib.purdue.edu/larstech/27*

4.Drost, D.2010.Sweet Corn in the Garden. Utah State University, Cooperative Extension. (HG/Garden/ 2005-10pr). *https://extension.usu.edu/files/publication.*

5.Elsahookie, M.M. 1990. Maize Production and Breeding. Ministry of Higher Education and Scientific Research. University of Baghdad, pp. 400.

6.Fekonja,M., F.Bavec, S.Grobelnik-Mlakar, M.Turinek, M.Jakop and M.Bave.2011.Growth performance of sweet maize under non-typical maize growing conditions. Biological Agriculture and Horticulture, 27:147–164.

7.Fritz,V.A., C.B. Tong, C.J.Rosen and J.A.Wright.2010.Sweet corn (vegetable crop management),University of Minnesota, extension. *http://www.extension.umn.edu/garden*

8.Hart, J.M., D.M. Sullivan, J.R. Myers, and R.E. Peachey.2010. Nutrient Management Guide, Sweet Corn. Oregon State Univ. Extension service, pp: 21.

9.Hochmuth, G. and E.D. Hanlon.2013. A Summary of N, P, and K Research with Sweet Corn in Florida. Fla. Coop. Ext. Serv. Cir. SL. pp: 326.

10.Kar,P.P., K.C. Barik, P.K. Mahapatra, L.M. Garnayak, B.S. Rath, D.K. Bastia and C.M. Khanda.2006.Effect of planting geometry and nitrogen on yield, economics

and nitrogen uptake of sweet corn (*Zea mays*). Indian Journal of Agronomy,51(1):43-45.

11.Lazcano, C., Revilla, P., Malvar, R. A. and Domínguez, J. 2011, Yield and fruit quality of four sweet corn hybrids (*Zea mays*) under conventional and integrated fertilization with vermicompost. J. Sci. Food Agric., 91: 1244–1253

12.National Bureau of Agricultural Commodity and Food Standards Ministry of Agriculture and Cooperatives.2012. Thai Agricultural Standard, TAS 1512-2011. Published in the Royal Gazette Vol.129 Section 14D Special, Dated 10 January B.E. 2555.pp:17.

13.Ramankutty,N., J.A. Foley, J. Norman and K. McSweeney. 2002. The global distribution of cultivable lands: Current patterns and sensitivity to possible climate change. Global Ecol. Biogeography. 11:377–392.

14.Madhava Rao,K.V.,A.S. Raghavendra, K. Janardhan Reddy.2006. Physiology and Molecular Biology of Stress Tolerance in Plants. Printed in the Netherlands, Springer. pp: 1-14.

15.Shaheenuzzamn.M, R. R. Saha, B. Ahmed, J. Rahman, and A. Salim.2015.Green cob and fodder yield of sweet corn as influenced by sowing time in the hilly region. Bangladesh J. Agril. Res., 40 (1): 61-69.

16.Szymanek, M., B. Dobrzañski jr, I.Niedziólka and R. Rybczyñski.2005. Sweetcorn, Harvest and Technology, Physical Properties and Quality. Centre of Excellence Agrophysics for Applied Physics in Sustainable Agriculture;B. Dobrzański institute of Agro physics of Polish Academy of Sciences, Poland,pp:234.

17.Tolenaars, J.2013. Corn maturity and heat units. University of Guelph. Cited from http://www.plant.uoguelph.ca.

18.Ugur, A. and H. A. Maden.2015. Sowing and planting period on yield and ear quality of sweet corn (*Zea mays* l. Var. Saccharata). Ciênc. Agrotec, 39 (1): 1413-7054.

19.Wang.Q.Y. Jiang and L. Guilan.2006. Effect of nitrogen and potassium on grain yield and quality of sweet maize.Jor. ofMaize Sciences, 03.

20.Warman, P.R. and K. H. Harvard. 1996. Yield, vitamin and mineral content of four vegetables grown with either composted manure or conventional fertilizer. Journal of Vegetable Crop Production 2(1): 13-25.

21.Warman, P.R. and K.H.Harvard.1998. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet corn. Agriculture, Ecosystems and Environment,68(3): 207–216.

22.William, M.2014.Better sweet corn research, better production. ACES.College of Agricultural, Consumer and Environmental SciencesACES News and Public Affairs.University of Illinois, Urbana, Illinois, USA. http://www.uiuc.edu