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Effect of Nitrogen Fertigation via Two Methods of Sprinkler and Furrow Irrigation under Different Levels of Fertilizers on Yield and Yield Components of Sweet Corn

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Abstract: Application of fertilizers through irrigation systems or fertigation is one of the most efficient methods of fertilization. Fertigation method based on the need for nutrients placed at the disposal plant in optimal moisture conditions. Using this method makes it possible to provide a nutrient for the plant in moisture near the roots' area, where the local nutrient absorption by roots is maximal. A research was performed in the years 2007 and 2008 in Gorgan Agricultural Research Station on the golden grain varieties of sweet corn (SC403), in order to investigate the effectiveness of fertigation with different nitrogen fertilizer and irrigation methods on yield and yield components of sweet corn. In this study, a randomized complete block statistical design was performed on a field with dimensions of 100 in 80 meters with three replications. Treatments included a sprinkler irrigation and furrow irrigation. Fertigation treatments included 200 and 300 kilograms per hectares (N_{200}, N_{300}) of nitrogen fertilizer in each segment, given to the plant in two stages. Soil samples were taken from the depth of 100 cm of the selected field and physical and chemical analysis was done on them in order to be used later for the interpretation of results. At the end of the growth period, plant samples obtained from repetitions of each treatment and determining yield, were sent to the laboratory to measure their weight and total wet and dry mass (biomass). Results showed that irrigation method significantly influence yield and yield components of sweet corn at 1% level and the maximum values of grain yield (3611 kg per hectare) were observed in sprinkler irrigation and a minimum yield (2945 kg per hectare) were observed in furrow irrigation. Nitrogen fertilizer had the significant impact at 5% level on yield and dry matter yield and maximum dry matter production and grain yield was observed in treatments N_{200}. Nitrogen fertilizer had no significant effect on yield and wet mass yield.

Key words: Fertigation · Sprinkler irrigation · Furrow irrigation · Sweet corn · Golestan

INTRODUCTION

Concerns about best management practice are increasing, since the mismanagement of nitrogenous fertilizers can lead to contamination of ground and surface water sources as well as soil degradation. High nitrate concentrations can cause water pollution [1]. A way of managing nitrate pollution is to introduce an alternative Irrigation method that reduces chemical transport through soils, as well as the amount of applied water. Consumption of nutrient elements through the irrigation systems is called fertigation. In this method, the plant is provided with necessary nutrients based on ideal moisture conditions. Applying optimal ways of fertigation

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requires information on plant characteristics such as daily food consumption and distribution of roots in soil, recognition of food features, including solubility and transfer of irrigation water quality factors such as an acidity, salinity levels and organic matter [2].

Nutrient uptake during plant growth varies. Depending on the type of the food factor, each plant has maximum amount of demand for food elements. In some plants, the maximum time of the greatest need or stage of reaction to the food elements, is the early stages of the growth period and in some other, is later stages. The purpose of scheduling and planning for fertilizer is to obtain the best response to the fertilizer. With the elements making food available at the time of maximum need, most fertilizer efficiency and maximum performance are achieved. Knowing the time when the plant needs food elements, the amount of available nutrient elements in the soil and food uptake by plant, the amount of fertilizer consumption can be set for each fertigation stage. In fact, fertigation biggest advantage over other methods of fertilization is providing nutrient elements needed by plants in the growth process and thus is efficient fertilizers [3]. Factors affecting the type of irrigation system are uniformly distributed fertilizers, because the uniformity of fertilizer distribution affects directly uniformity of irrigation. For the efficient use of fertigatin, fertilizer should include most nutrient elements needed by plants in a usable form for plants (forms that easily change). Nitrogen is the most common and most consumed food elements through irrigation methods. Suitable urea nitrogen fertilizers are to be used in fertigation. This fertilizer is a neutral molecule and highly soluble. Between the 13 required food elements, nitrogen, phosphorus, potassium, zinc and Bore are more important for sweet corn feeding in calcareous soils of Iran are. However, depending on soil and environmental conditions, some other elements could also be factors, limiting the growth. Research shows that the nitrogen is the main bottleneck sweet corn production, especially in arid and semiarid regions. Nitrogen in these areas is the first element that is considered deficient. In these areas, the amount of soil organic matter which is the main source of nitrogen is low, because of different reasons, including low rainfall, poor crop rotation, minimal vegetation and lack of animal and green manure fertilizer consumption. Plant can absorb nitrogen in the forms of NO3 and NH_4. Nitrogen causes creating a natural green color, rapid development, increasing the stem and leaves, enhancing and increasing the amount of wheat protein products [4].

Irrigation method is one of the important parameters used in decision making in fertigation. Fertigation sprinkler irrigation method in low volume and light, done with continuously and in short intervals during the season. This reduces the waste of water, especially in soils with high permeability and makes the irrigation is highly efficient. Soil conditioning will be done properly and the plants will be less affected by periods of drought or water stress and high moisture content of soil minerals. With short distances of water intake, the soil solution is often diluted and plant will not be influenced by high concentration of soil solution. Irrigation helps water to penetrate and move in all dimensions of the soil and unlike surface irrigation, gravitational movement of water is not very high. This causes the roots to maintain nutrient elements in the environment and reduce leaching and thus can be implementing this system, the fertile lands of non-cultivable construction. Water distribution in this way does not depend on the topography of the farm level, water distribution in the field to take place smoothly without leveling. Sprinkler irrigation systems, water plants directly in contact with the surface and in case of food consumption with water, allowing absorption of nutrients from aerial plant is possible. For this purpose, the food concentration in irrigation water must be as low as possible. In the case of fertilizing through irrigation, nutrient absorption, including micronutrient will be directly from leaf. This is very important in greenhouses and large leaf covering products. The other advantage of this method like other methods of irrigation is water use and precise control of the irrigation system [5]. Fertigation rate in shallow water loss through runoff, evaporation and deep penetration is higher. Therefore, water use efficiency is low and loss of fertilizer will be caused by this way of fertilizer consumption. Water distribution on the ground is done by the slope of the ground without any mechanical tools. The simple appearance of this method is misleading. Proper control of highly variable water movement in soil and water penetration into the soil through the entire season is very difficult and it seems to be the most sophisticated method for the use of water. So fertilizer management in this method is very difficult. Water distribution and distribution in the Earth's surface during the growing season are not usually uniform. This factor is the most important reason for the low efficiency of surface irrigation methods. So the application of fertilizer in this way can exacerbate the negative effects of the non-uniform irrigation. Despite the low efficiency of

nutrient elements used in this method in comparison with other methods of irrigation, proper management of water and fertilizer can significantly increase the fertilizers use. Fertilizer irrigation in some surface irrigation ways, Including a Furrow irrigation and row irrigation, is easier and more efficient than the methods using conventional fertilization methods. Relatively uniform distribution of fertilizer over the soil surface may be possible when the soil surface is relatively flat and water space is faster than penetration speed [6].

Gaucho took a five-year experiment in the U.S. state of Georgia to determine N fertilizer use efficiency, with two fertigation sprinkler systems and fertilizer systems conventional fertilization methods (in-band insertion) on corn nitrogen fertilizer ranges from 168 to 350 kg per ha. Results showed that in application of 280 kg N per hectare, maximum yield is achieved. In that year, the average rainfall occurred in band fertilizer combination of implantation in the early growing season, late growing season fertigation highest yield and maximum efficiency of nitrogen fertilizer were followed [7]. Bullock tested the effect of nitrogen through the irrigation system, central circular type and nitrogen use efficiency of corn seed in a loamy sand soil. The results showed that increasing the amount of nitrogen from 168 to 336 kg per hectare and the rate of 8 / 37 kg nitrogen per hectare per cubic meter did not increase nitrogen use efficiency. Most performance achieved by taking 168 kg N ha respectively. This amount is equivalent to 60 percent of fertilizers in common fertilization methods [8]. Smika showed that nitrogen fertigation through irrigation in five steps rather than once in a sandy soil, nitrate leaching greatly reduces, thereby persistence of nitrogen in soil increases [9]. Granberry reported that with the implementation of the fertigation method, crops can be consumed from 20 to 50 percent less fertilizer than the current methods of fertilization, better performance and higher quality achieved [10]. Li studied the effect of uniformity of sprinkler irrigation on deep percolation distribution of nitrogen in soil, N uptake by plants and yield of received and expressed that use of sprinkler irrigation to spread fertilizer increased uniformity and efficiency of fertilizer distribution [11]. Considering that the effect of irrigation method and nitrogen fertilizer levels on the yield product efficiency is different in this study evaluated the effect fertigation via furrow irrigation methods under different levels of nitrogen fertilizer on yield and its components in the sweet corn.

MATERIAL AND METHODS

The research was carried out during 2007 and 2008, in Gorgan Agricultural Research Station affiliated to Agriculture and Natural Resources Research Center of Golestan Province, within 6 km north of Gorgan city 54.20° longitude and, 36.55°latitude within 6 meters above sea level, with average annual rainfall of about 450 mm in area and clay loam soil type in about 30 cm depth. Table 1 shows the physical characteristics of soil and its chemical characteristics are listed in Table 2.

Table 1: Physical characteristics of soil in testing area

Soil depth (cm)	Bulk density (gr/cm^3)	Saturation SP	Permanent wilting point (weight %) PWP	Field capacity (weight%) FC	Soil texture	Percent of soil particles Sand	Silt	Clay
0-20	1.44	49.9	13.1	27.7	Silty clay loam	18	50	32
20- 40	1.41	52.2	12.3	27	Silty clay loam	18	48	34
40-60	1.4	51.9	9.8	27.6	Silty clay loam	18	48	44
60-80	1.44	47.4	8.9	27	Silty clay loam	20	48	32
80-100	1.39	46	11.1	27	silty loam	22	50	28

Table 2: Chemical characteristics of soil in testing area

Soil depth (cm)	Organic carbon OC (%)	Organic matter OM (%)	Total nitrogen (%)	Acidity (%)	EC ds/m	Percent can exchange cations (CEC) me/100g	Phosphorus and potassium (PPM) K	P
0-20	1.3	2.24	0.16	7.1	1.96	20	11.3	393
20- 40	1.24	2.13	0.17	7.3	2.13	13.5	11.8	393
40-60	0.68	1.17	0.12	7.5	1.29	9	5.9	287
60-80	0.62	1.07	0.15	7.6	1.2	8.5	2.3	190
80-100	0.36	0.67	0.05	7.5	1.16	7	1.8	141

In this study, a randomized complete block statistical design applied on a part of land with dimensions of 100 meters in 80 treatments, including two irrigation methods (sprinkler irrigation and furrow irrigation) and for each of these two methods of irrigation treatment levels of 200 and 300 kg of nitrogen fertilizer (N_{200} and N_{300}) in a hectare with three replications was carried out. Sprinkler irrigation plots for the classical system are fixed Sprinkler Nozzle VYR two adjustable 12 in 12 m intervals were used. Major and minor aluminum pipes with a diameter of three inches, were fed by hydrant from the underground network of pipes and for furrow irrigation treatments a system of gated pipes with 8 inches diameter in the open-end furrow and no cut back, were used. Furrow lengths are 100 meters and a distance between the furrows was 75 cm which has been installed against the furrow and 75 cm intervals on the pipe valve. According to the technical advice and test soil, 180 kg of ammonium phosphate fertilizers and 140 kg of ammonium nitrate fertilizer given to the soil was before planting, mixed with soil after distribution by the disc. The remaining nitrogen fertilizer was given to the plant based on each form of treatment in two parts. Type of fertilizer used for fertigation operations was urea. In furrow treatments water is mixed with fertilizer in barrels with tap and fertigation is done by placing barrels at the beginning of furrows. Sprinkler system and the amount of fertilizer required per treatment that was mixed within a barrel along with water and was injected into the irrigation system through a ventory. In each fertigation, the irrigation is run for an hour to raise the osmotic potential of plant and soil matrix potential as well and then the fertilizer was injected. After injecting fertilizer sprinkler irrigation system, the irrigation practice continued until the remaining fertilizer on the leaves and in the pipes was washed. In each operation fertigation for N200 treatments amount to 100 kilograms per hectare and the amount of N300 treatments 150 kilograms per hectare of fertilizer with irrigation water was provided to the plant. During the test for determining the timing and depth of irrigation water based on soil moisture monitoring, soil samples were regularly transferred to the laboratory each two day from the beginning, middle and end of each plot (5 samples each) from the depth of 30 cm to determine supply and Soil moisture content by weight. In furrow irrigation in each irrigation period, water speed and time for the water front to reach the nails marks along the furrows were recorded. Quantitative characteristics and agronomic characteristics in each plot were calculated at the end of the growing season, including plant height, leaf number, leaf area index (LAI), leaf length, ear number per plant on weight, ear length, stem and leaf weight, ear weight of wood and bark, wet weight and total dry air mass (biomass).

RESULTS AND DISCUSSIONS

Analysis of variance and yield components of sweet corn during 2007 and 2008 are presented in Table 3. According to Table 3 ear function during different years at 5% level was significant. Grain yield and other yield components did differ significantly. Differences between treatments in terms of irrigation method and ear grain weight and total wet and dry air mass (biomass) at 1% level was significant. There were significant differences between different levels of nitrogen fertilizer and the total yield of dry air mass (biomass) at 5% level, but in terms of yield per ear and total wet weight, there was no significant difference. Comparison of yield and yield components of sweet corn during 2007 and 2008 in different treatments are presented in Table 4. According to Table 4, maximum values of yield rate of 3611 kilograms per hectare,

Table 3: Analysis of variance and yield components of sweet corn affected by fertigation treatments in the years 2007and 2008

Mean Square					
Total dry air mass (biomass)	Grain Yield	Ear Yield	Wet weight of the total air mass	Degrees of freedom	Error Sources
17614780.04**	2658672.67**	13943077.04**	459576272.0**	1	irrigation (A)
2230902.92 n.s	47001.583 n.s	773790.42 n.s	3356762.9 n.s	4	Repeats (R)
762197.04 n.s	224653.50 n.s	5214540.38*	22301176.0 n.s	1	Years (Y)
74928.38 n.s	1028376.0 n.s	3604525.04 n.s	3613832.0 n.s	1	Error (A * Y)
272381.08 n.s	1128042.50*	2727927.58 n.s	6563987.2 n.s	4	Error (R * Y)
11194370.04*	1932337.50*	2241759.38 n.s	5274375.0 n.s	1	fertilizer (N)
3688720.04 n.s	1198854.0 n.s	2942100.37 n.s	64232632.0 n.s	1	Error (A * N)
2780523.38 n.s	99588.167 n.s	120558.38 n.s	14438259.4 n.s	1	Error (N * Y)
1332459.38 n.s	10.667 n.s	562122.04 n.s	4337550.4 n.s	1	Error (A*Y*N)
1218880.33	256438.46	853216.17	14125977	8	test error
22.221	15.445	13.055	15.078	-	coefficient of variation

*, ** And n.s respectively indicate significant difference at 5 percent, 1 percent and no significant difference

Table 4: Comparison of performance and implementation of sweet corn yield in different treatments of irrigation and nitrogen fertilizer in the years 2007 and 2008

Total dry air mass (biomass)	Grain Yield (kg / ha)	Ear Yield (kg / ha)	Wet weight of the total air mass(kg / ha)	Treatments
5146.5a	3375.5a	7541.3a	25891a	Year2007(Y1)
4790.1a	3182.0a	6609.1b	23963a	Year2008(Y2)
5825.0a	3611.6a	7837.4a	29303a	sprinkler irrigation (A2)
4111.6b	2945.9b	6313.0b`	20551b	furrow irrigation (A2)
5651.3a	3562.5a	7380.8a	25396a	Fertilizer N200(N1)
4285.3b	2995.0b	6769.6a	24459a	Fertilizer N300 (N2)
5947.3a	3501.3ab	7916a	29879a	interaction (Y1*A1)
4345.7ab	3249.7ab	7166.7a	21903b	interaction(Y1*A2)
5702.7a	3721.8a	7758.8a	28727a	interaction (Y2*A1)
3877.5b	2642.2b	5459.3b	19199b	interaction (Y2*A2)
6169.8a	3723.7a	7917.8a	27136a	interaction (Y1*N1)
4123.2b	3027.3a	7164.8a	24647a	interaction (Y1*N2)
5132.7ab	3401.3a	6843.8a	23657a	interaction (Y2*N1)
4447.5ab	2962.7a	6374.3a	24270a	interaction (Y2*N2)
6900a	4118.8a	8493.2a	31408a	interaction (A1*N1)
4402.5b	3006.2b	6268.5b	19384c	interaction (A2*N1)
4750b	3104.3b	7181.7a	27199b	interaction (A1*N2)
3820.7b	2885.7b	6357.5b	21719c	interaction (A2*N2)
7598.3a	4072.3a	8795.7a	33185a	interaction (Y1*A1*N1)
4741.3bc	3375ab	7040ab	21087de	interaction (Y1*A2*N1)
4296.3c	2930.3a	7036.3ab	26574bcd	interaction (Y1*A1*N2)
3950c	3124.3ab	7293.3ab	22720cde	interaction (Y1*A2*N2)
6201.7ab	4165.3a	8190.7a	29631ab	interaction (Y2*A1*N1)
4063.7c	2637.3b	5497b	17682e	interaction (Y2*A2*N1)
5203.7bc	3278.3ab	7327ab	27823abc	interaction (Y2*A1*N2)
3691.3c	2647b	5421.7b	20717de	interaction (Y2*A2*N2)

yield per ear equal to 7838 kg per hectare, the total weight of the wet mass of air equivalent to 29,303 kilograms per hectare and total dry mass of air to the amount of 5825 kilograms per hectare were related treatments the sprinkler irrigation. Comparing data for nitrogen fertilizer showed that the difference between grain yield and total dry air mass was significant and the maximum of these amounts to 3562 kilograms per hectare of grain and 5651 kilograms per hectare for a total dry weight of air mass 200 kilograms of nitrogen fertilizer treatments were observed. Different levels of nitrogen fertilizer had a significant effect on yield and total production of the ear wet weight of the air mass of sweet corn. Similar to the results obtained in this research study, Sexton [12] showed that with 202 kg of maize per hectare of urea fertilizer per year maximum grain yield is produced. Comparison table of sweet corn yield data with regard to the interaction effect of irrigation method, nitrogen fertilizer rates in both 2007 and 2008 showed that differences between different treatments were not significant. Maximum yield rate of 4165 kilograms per hectare was observed in N_{200} sprinkler fertigation treatments in 2008 and minimum amount of 2637 kg per ha of grain in a furrow fertigation N_{200} treatment was obtained in the same year. Interaction effects of irrigation methods, different levels of nitrogen fertilizer and different years on ear yield suggests that maximum performance of the ear in N_{200} irrigation fertilizer treatments, at the first test in 1386, was achieved about 8769 kg per ha and the minimum was observed in furrow irrigation fertilizer treatments N_{300} with a value of about 5422 kg per hectare. Maximum amounts of wet weight and total dry weight according to the following pictures was observed in N200 fertigation treatments in 1386 and the minimum amounts of these parameters was observed in a N300 furrow irrigation fertilizer treatments in 1387. Similar results achieved by Gaucho (Gaucho *et al.* 1984), Bullock (8), Smika (9), Granberry (10) and they concluded that with implementation of sprinkler fertigation methods and consumption of nitrogen fertilizer between 168 to 202 kg per hectare for corn better performance and higher quality can be achieved by reducing the fertilizer from 20 to 50 percent compared to conventional fertilization methods.

Conclusions and Recommendations: According to the results of yield and yield components of sweet corn, the best nitrogen fertilizer consumption level and irrigation treatment in the testing field was sprinkler fertigation treatments with 200 kg per hectare consumption of nitrogen fertilizer. While the weakest results related to the fertigation treatments of furrow irrigation and the consumption level of 300 kg per ha of nitrogen fertilizer in two years. Therefore, it is recommended that due to the critical problem of underground water pollution with nitrates and its indiscriminate leaking to these sources, the exact amount of fertilizer needed in each region based on soil type, water quality and weather conditions in the

area is to be determined by the researchers and be proposed to farmers to increase the fertilizer use efficiency and reduce environmental pollution risks. For optimal utilization of available water resources, increasing water and fertilizer uniformity, irrigation method is recommended to be used for planting corn varieties, also since the cost of providing sprinkler irrigation systems with fertilizer injection equipments is low. It is recommended to equip sprinkler irrigation systems with fertilizer injection at the same time of the irrigation system set up, in order to control fertilizer consumption during the consumption to increase fertilizer use efficiency and decrease nitrate leakage losses into underground water, caused by its indiscriminate use.

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