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Evaluation of Nitrogen Fertilizer and Plant Density on Chemical Analysis of Corn Forage and Weed Population in an Agroforestry System

S. Ghanbarzade, M.R. Chaichi*, S.M.B. Hosseini and A. Sadeghpour
University College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran
E-mail: rchaichi@ut.ac.ir

Agroforestry is one of the aspects of sustainable agriculture in which woody perennials are deliberately integrated with crops and/or animals in the same place, in the same time or both. This study was conducted to analyze the effects of nitrogen fertilizer and corn density under the canopy of orange trees on forage chemical analysis and weed populations. In this experiment, 4 levels of nitrogen fertilizer (0, 100, 200 and 300 kg/ha) and 4 different levels of corn densities (80000, 110000, 140000 and 170000 plants/ha) were used in a split plot arrangement based on randomized complete blocks design with three replications in Babol (Babol kenar region), Iran. The increasing of nitrogen fertilizer caused a raise in crude protein percentage and the highest percentage of crude protein was obtained in the 300 kg/ha nitrogen fertilizer and population of 110000 plant/ha. The highest digestive dry matter was yielded in the 200 kg/ha of N fertilizer and 110000 plant/ha. Moreover, by increasing of nitrogen fertilizer and sowing rate, weeds dry matter decreased and the lowest amount of weeds biomass was observed in 300 kg/ha nitrogen fertilizer and sowing density of 170000 plant/ha.

Key Words: Corn, Nitrogen fertilizer, Plant density, Forage chemical analysis, Agroforestry.

INTRODUCTION

Based on the vast citrus farms in the northern parts of Iran and according to the great needs of producing forages in the country, agroforestry is the utmost important system for efficient use of resources and the lands under cultivation. Agroforestry is a collective name for land use systems in which woody perennials are deliberately integrated with crops and/or animals on the same land unit. The integration can be either in a spatial mixture or in a temporal sequence. There are both ecological and economic interactions between woody and non-woody components in agroforestry.

Competitive effects of hybrid poplar and silver maple such as shading and competition for soil moisture were studied on under-story crop net assimilation, growth and yield of corn and soybean. Tree competition significantly reduced photosynthetic radiation (PAR), net assimilation growth and yield of individual soybean or corn plants growing nearer (2 m) to tree rows. Net assimilation was highly correlated with yields more than other parameters and poplar rather than maple, had the highest competitive effect on net assimilation[1].

Absorption and transfer of phosphorous was studied in the soybean-citrus intercropping system by using a P^{32} tracer technique. Total phosphorus absorption and accumulation in soybean organs decreased significantly under the intercropping compared to the monoculture. With intercropping, when P^{32} was applied in topsoil, total P^{32} absorption in soybean was significantly lower, but when P^{32} was applied to deeper soil layers, P^{32} in soybean was significantly greater[2].

According to Aydin and Uzun[3], nitrogen and phosphorus fertilization of rangelands affected yield, forage quality and the botanical composition. The economic optimum was found with the highest fertilizer doses providing 52 kg P ha^{-1} + 180 kg N ha^{-1} producing 4810 kg ha^{-1} forage dry matter with a crude protein content of 124 g kg^{-1}.

In a comparison of synthetic with organic nitrogen fertilizer (livestock manure and green manure), the results showed that although using green manure could prove useful in nitrogen and phosphorus cycling in a long period of time, inorganic nitrogen significantly increased the yield in a short period[4].

Black walnut and honey locust tree were intercropped into tall fescue. Increasing tree density affected nonstructural carbohydrates in forage and honey locust, rather than black walnut, had higher crude protein. Presence of tree in the cropping system had both positive and negative effects on forage quality[5].

Producing forage, especially silage corn, is in the priority for farmers in Mazandaran province, Iran. Due to the limitation of farm lands in the region, study on forage crops, particularly silage corn, under the canopy of citrus plants is substantially needed. The main objective for corn planted into citrus trees was to evaluate the effect of nitrogen fertilizer and plant density on forage yield and chemical analysis of corn forage.

The main objectives of this study were determining the best nitrogen fertilizer level on the corn forage quality under the canopy of citrus trees, determining the most efficient corn population in the agroforestry system with citrus trees and finally study the effects of intercropped corn and citrus trees on weed population.

EXPERIMENTAL

The experiment was conducted during growing season 2006-2007 in a farm located in Babolkenar region (36° 34′ N, 52° 44′ W), Mazandaran province, Iran. The mean altitude was 2 m below the free sea level. Also, average annual rainfall and mean annual temperature of the site were 800 mm and 16 °C, respectively. The soil was classified as sandy-loam soil with pH = 7.5, mineral carbon 9.6 %, total nitrogen 0.11 mg kg^{-1}, total available P 39.1 mg kg^{-1} and total available K of 226 mg kg^{-1}.

This experiment was carried out to study the effects of nitrogen fertilizer and corn planting density on morphological, agronomical and horticultural characteristics of silage corn (Zea mays, cultivar 704), orange (Tompson, cultivar Novel) trees and weed population characteristics in an agroforestry system.

The experimental design was split plots in randomized complete block design with three replications. In this experiment, 4 levels of nitrogen fertilizer in form of ammonium sulfate (0, 100, 200 and 300 kg/ha) were allocated to main plots. The nitrogen fertilizer was applied at three different times. The subplots consisted of four different levels of corn densities (80000, 110000, 140000 and 170000 plants/ha) which were randomly assigned to each plot. According to the experimental design, total numbers of treatments were 16 which were put into three blocks. Each block consists of 16 plots that were placed among trees. Trees were planted at a spacing of 600 cm × 600 cm. The average crown and canopy diameter of the trees were approximately 3 m/tree. Experimental plots were placed between two rows of trees with a space of 1.5 m from each. The field was cultivated by garden tractor and ridges and furrows were built to irrigate the field.

Corn seeds viability was tested and seeds were disinfected by fungicide, carboxyl tiram, before they were seeded. Phosphorous in form of triple super phosphate, was applied in amount of 250 kg/ha and placed in the soil at the depth of 5 cm. The first portion of N fertilizer *i.e.*, ammonium sulfate was applied before planting of the corn seeds. Five branches of orange trees were chosen from each side of experimental plots and were marked by a red string (during experimental period) to measure some orange fruit parameters.

A one meter square quadrate was used for counting weeds and their dry matter in each plot. Due to heavy rains in the whole growing periods, the field was irrigated only two times. Thinning was applied in four-leaf stage. No pests or diseases were observed during growing season hence, no pesticides were used. The two last proportions of ammonium sulfate fertilizer were applied in 8-leaf and the beginning of flowering stages, respectively.

Corn was harvested at early milk stage. On sampling occasions, one sowing row on each side of each experimental plot as well as 1 m from the beginning and 1 m from the end, were omitted to avoid border effects. The rest of the plot area was harvested as yield for each experimental treatment. Weeds biomass and number were sampled from the center of each experimental plot by means of 2 quadrate (2 m^2) samples consisting of weeds in middle rows in each plot, regarding to border effects. Weeds were counted and after being harvested were placed in oven for dry matter measurements.

The measured parameters consisted of forage qualitative characteristics (crude protein, fiber, total dry matter digestibility and water soluble carbohydrates) and weeds dry matter. To evaluate forage quality, the samples were milled and then the qualitative characteristics were measured by NIR8620 machine being calibrated by conventional laboratory methods beforehand. Orange fruit diameters on each detected branch were measured by cullies to evaluate the corn treatment effects on surrounding trees.

RESULTS AND DISCUSSION

Forage quality

Dry matter digestibility: The ANOVA for nitrogen fertilizer and plant density did not show a significant effect on dry matter digestibility, but there was a significant interaction between nitrogen fertilizer and plant density for dry matter digestibility ($p < 0.05$) (Table-1). The greatest dry matter digestibility was obtained in 200 kg/ha fertilizer N and 110000 plant/ha (Fig. 1). By increasing of fertilizer N, crude protein percentage increased. However, there was a negative correlation between increasing of nitrogen fertilizer and dry matter digestibility. Therefore, corn responded to low fertilizer N level because of its effect on dry matter digestibility. Ward *et al.*[6], also claimed that there is a negative correlation between dry matter digestibility and CP, ADF and ASH of tropical grasses.

TABLE-1
ANOVA FOR CORN FORAGE QUALITY UNDER NITROGEN FERTILIZER AND PLANT DENSITY TREATMENTS

SOV	Df	DMD	CP	CP	WSC	ADF
Replication	2	2.373 ns	1.802 ns	228737.870 ns	63.17 ns	2.017 ns
Fertilizer N (A)	3	1.338 ns	9.085*	1538163.460*	69.28 ns	7.815 ns
$Error_a$	6	1.397	2.528	216320.983	4.585	5.706
Plant density (B)	3	0.456 ns	3.387 ns	417852.916 ns	3.062 ns	1.063 ns
Interaction (AB)	9	9.094*	6.583*	350841.899 ns	4.607*	9.290*
$Error_b$	24	2.83	1.789	171907.428	1.987	2.123
CV	–	2.83	10.90	11/61	9.150	4.430

*Significant difference at ($p < 0.05$), nsno significant difference.

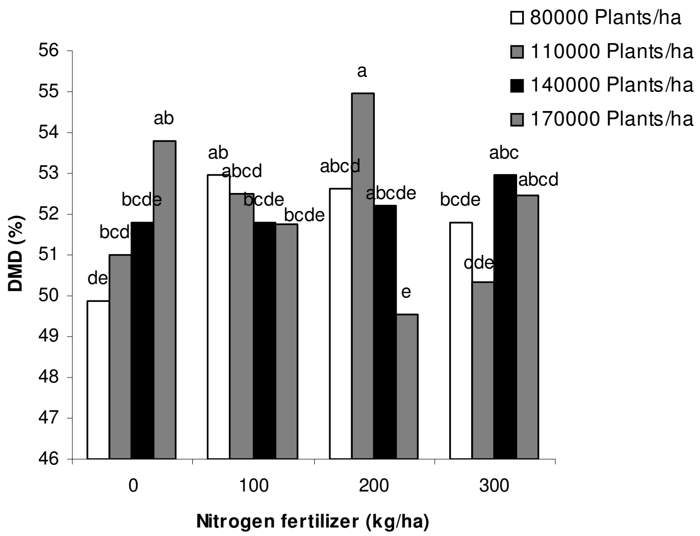

Fig. 1. Interaction of fertilizer N and plant density on dry matter digestibility of corn (SC 704) in Babol region (Babolkenar)

Crude protein (CP): Crude protein of corn was affected by nitrogen fertilizer (Table-1). The highest crude protein was gained in 300 kg/ha of nitrogen fertilizer. In fact, there was no significant difference among this level of fertilizer N and other nitrogen fertilizer levels. However, there was a significant difference between control (no fertilizer) and 300 kg/ha fertilizer N level (Figs. 2 and 3). Generally, nitrogen is involved in the process of producing amino acids, vitamins and chlorophylls. Sufficiency of available nitrogen can increase corn growth rate and positively affect storage of protein materials which is a qualitative characteristic for corn[7]. The highest crude protein was yielded from 133 kg/ha pure nitrogen fertilizer in Varamin[8]. It is clear that increases in the availability of nitrogen for medics; elevate their nitrogen and consequently crude protein contents[9]. Therefore, this could be the reason for crude protein increment with respect to more nitrogen fertilizer application in this experiment.

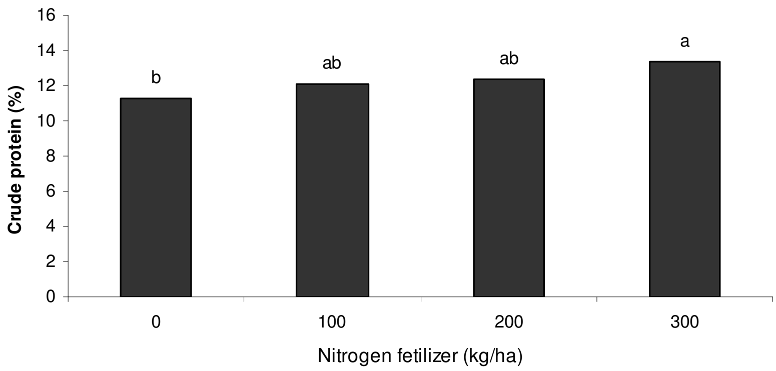

Fig. 2. Effect of nitrogen fertilizer on crude protein of corn (SC704) in Babol region (Babolkenar)

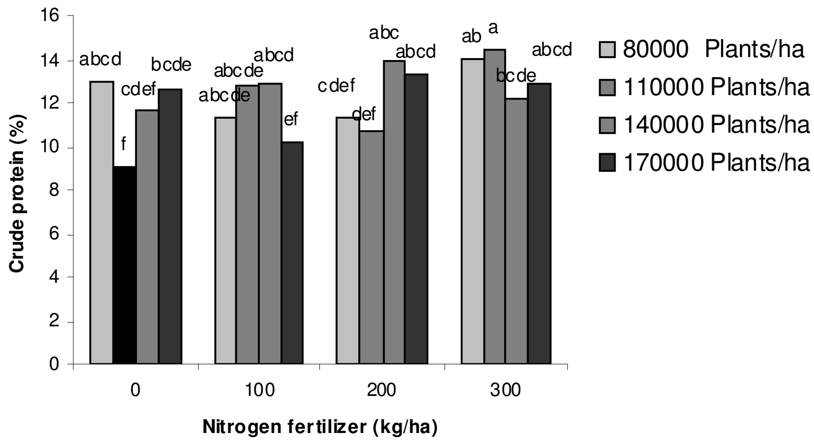

Fig. 3. Interaction of fertilizer N and plant density on crude protein percentage of corn (SC704) in Babol region (Babolkenar)

Although plant density had no significant effect on forage crude protein, there was a significant interaction between fertilizer treatments and plant density (Table-1). Effect of plant density and different levels of nitrogen fertilizer on crude protein didn't follow a particular order. Like other quality characteristics in cereals, crude protein is strongly affected by both environment and growth stage. Applying fertilizer N causes an increase in protein content and plant growth. This usually follows by decreasing in water soluble carbohydrates[10].

Protein yield: Protein yield was significantly ($p < 0.05$) affected by nitrogen fertilizer (Table-1). By increasing the amount of fertilizer N, protein yield increased and the maximum protein yield was obtained from 300 kg/ha nitrogen fertilizer. No significant differences among different nitrogen treatments were observed except for control treatment (no nitrogen fertilizer) which produced the minimum yield of 3100 kg/ha (Fig. 4). Normally, the increasing of nitrogen fertilizer application causes an increase in plant vegetative growth and plant protein content. This usually is followed by decreasing in water soluble carbohydrates[11].

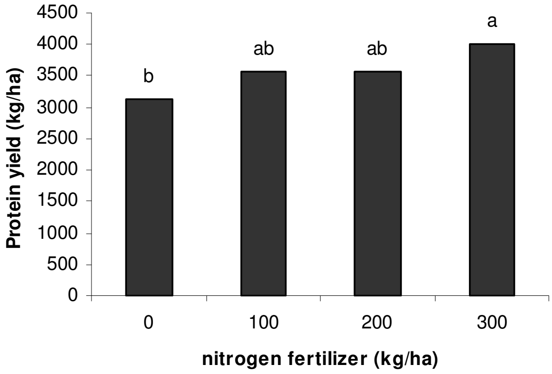

Fig. 4. Effect of nitrogen fertilizer on protein yield (kg/ha) of corn (SC704) in Babol region (Babolkenar)

Water soluble carbohydrate: Nitrogen fertilizer and plant density had no significant effect on water soluble carbohydrate while there was an interaction effect of plant density × nitrogen fertilizer on water soluble carbohydrate ($p < 0.05$) (Table-1). There was only significant differences between 110000 and 140000 plant/ha at 200 kg N/ha with lower densities at different N fertilizer applications. This shows that at lower N levels, because of less photosynthetic area, the carbohydrate content decreases in plant tissues. On the other hand, in higher plant densities, plants tend to accumulate less crude fiber which leads to a tender structure and an increase in water soluble carbohydrate. After studying on two different grass species, McGrath[12] stated that in initial stages of growth, carbohydrate store decreased. As photosynthesis started, water soluble carbohydrate increased and its increase continued to the beginning of flowering stage. Plant carbohydrate storage decreased because of its rapid growth in flowering stage (Fig. 5).

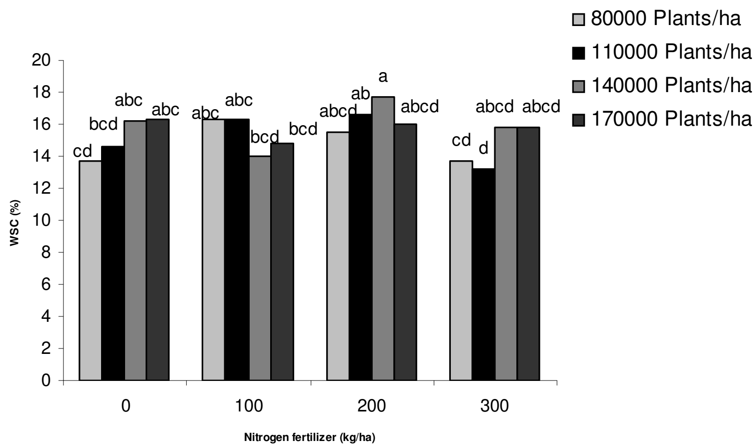

Fig. 4. Interaction of fertilizer N and plant denstiy on water soluble carbohydrate of corn (SC704) in Babol region (Babolkenar)

Acid detergent fiber: Even though nitrogen fertilizer and plant density had no significant effect on acid detergent fiber, their interaction significantly ($p < 0.05$) affected this characteristic (Table-1). In control treatment (no fertilizer), increasing in plant density led to a significant difference between the minimum (80000 plant/ha) and maximum (170000 plant/ha) plant densities. Moreover, the lowest amount of fiber was obtained at 200 kg/ha fertilizer N and 110000 (plant/ha) plant density. These results show that plant density can decrease acid detergent fiber only when no nitrogen fertilizer is applied[13]. It's obvious that in this case the difference in plant density must be significantly high (Fig. 6).

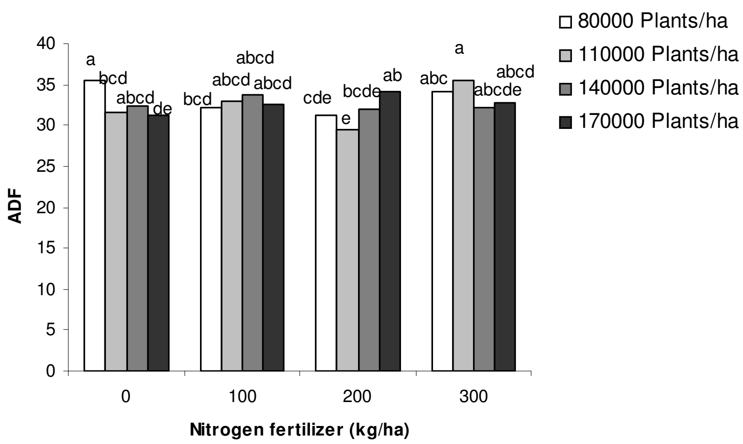

Fig. 5. Interaction of nitrogen fertilizer and plant density on acid detergent fiber of corn (SC704) in Babol region (Babolkenar)

Weeds biomass: The ANOVA shows that nitrogen fertilizer treatments significantly ($p < 0.05$) affected weed biomass (Table-2). The lowest dry weed biomass was recorded in 300 kg/ha nitrogen fertilizer which was significantly less than 100 kg/ha and control (no nitrogen fertilizer) treatments (Fig. 7). Corn is a C4 crop with a high nitrogen use efficiency which enables the plant to use nitrogen fertilizer sources more efficiently and develop a good canopy. This helps the plant to compete weeds more strongly which consequently decreases the yield loss. Tollenar *et al.*[14], studied mixed population of weeds and their effects on corn that yield loss decreased when more nitrogen fertilizer was applied.

TABLE-2
ANOVA FOR WEED BIOMASS AND FRUIT DIAMETER UNDER NITROGEN FERTILIZER AND PLANT DENSITY TREATMENTS

SOV	Df	Weed biomass	Fruit diameter
Replication	2	19/271 ns	0/003 ns
Nitrogen (A)	3	4035/24*	0/042*
$Error_a$	6	160/243	0/003
Plant density (B)	3	4172/743*	0/161*
Interaction (AB)	9	345/891*	0/103*
$Error_b$	24	68/750	0/003

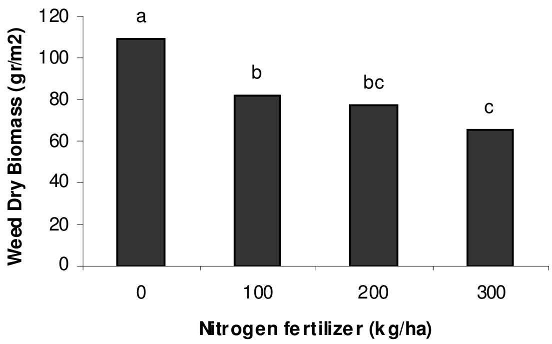

Fig. 7. Effect of nitrogen fertilizer on weed dry biomass of corn (SC704) in Babol region (Babolkenar)

Plant density treatments significantly ($p < 0.05$) affected weed dry biomass (Table-2). It was observed that by increasing plant density, weed dry biomass decreased and the lowest one was obtained in the density of 170000 plants/ha which was not significantly different from 140000 plant/ha. However, it was significantly higher than other density treatments (Fig. 8). These results indicate that by increasing plant density, plant canopy will cover the field surface more rapidly which will cause less light to reach to the weeds. This phenomenon will decrease weed competition ability. Weeds competition abilities are consisted of rapid germination, rapid root development, rapid early growth, high vigor, rapid leaf area and crown establishment, high LAD and height[15]. Soybean, wheat and corn rotation is a proper cropping system to compete with corn weeds. Corn planted on 50 cm row spacing will develop bigger crowns which enable it to complete the weeds more efficiently[14].

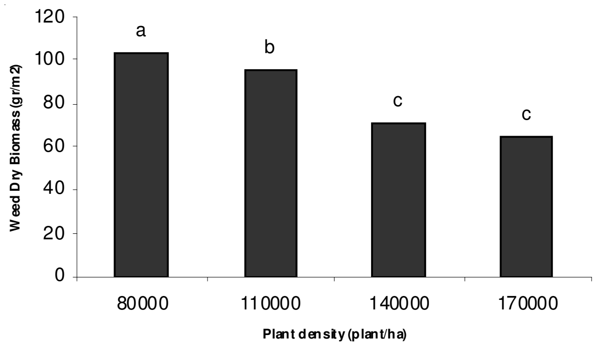

Fig. 8. Effect of plant density on weed dry biomass of corn (SC704) in Babol region (Babolkenar)

The ANOVA shows that interaction of plant density and nitrogen fertilizer had a significant ($p < 0.05$) effect on weed dry biomass (Table-2). As nitrogen fertilizer and plant density increased, weed dry matter decreased and the lowest weed biomass (417 kg/ha) was gained from 300 kg/ha nitrogen fertilizer and 170000 plant/ha plant density treatments (Fig. 9). These results indicated that increasing of both plant density and nitrogen fertilizer level negatively affected weed biomass and made the corn able to compete with weeds more effectively. Better crop management can increase plant ability to compete with weeds. Less row spacing, high plant density, seeding time and soil fertility can control weed suppression[16].

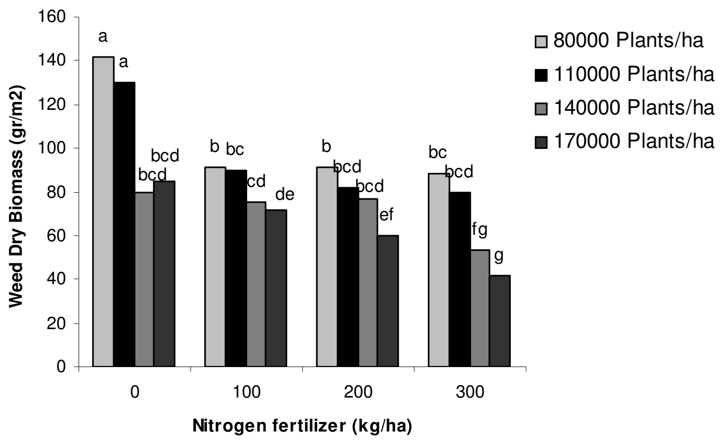

Fig. 9. Interaction of nitrogen fertilizer and plant density on weed dry biomass of corn (SC704) in Babol region (Babolkenar)

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