International Meeting on Soil Fertility Land Management and Agroclimatology. Turkey, 2008. p:403-411

Effect of Nitrogen Rates on Yield and Fruit Quality of Fig (*Ficus carica* L. cv. Sarılop)

Birgul Ertan[1] Ferit Cobanoglu[1] Berrin Sahin[1] Aytekin Belge[1]
Ramazan Konak[1] Mahmut Tepecik[2]
[1]Fig Research Institute, Erbeyli, Incirliova, 09600 Aydin, Turkey
Corresponding author: birgulertan @hotmail.com Tel:+90-256-5811123/26 Fax: +90-256-5811124
[2] Ege University, Agricultural Faculty, Department of Soil Science, 35100 Bornova-Izmir, Turkey

ABSTRACT

In this study, it is aimed to determine the effects of different nitrogen rates on yield and quality parameters, including aflatoxins in fig fruits (*Ficus carica* L. cv. Sarılop). For this study, one control and five different nitrogen levels were applied in a slope fig orchard in Egrek village in Incirliova, Aydin for two years. Yield, shoot length and some fruit quality parameters (cull ratio, ostiole width, color, brix and acidity) and aflatoxins were determined. An overall evaluation of fruit yield and quality notifies that up to 500g N/ tree can be recommended in the fertilization of fig according to findings of two years. However, it would be able to give absolute results from final report of that project in one year later.

Key words: Fig, quality, nitrogen, fertilization, and aflatoxin.

INTRODUCTION

It is estimated that Turkey produces 300.000 tons of fig fruit per year and The Aegean Region comprises 75% of the production. On the other hand, Turkey comprises about 55% of the total production of the world (Bülbül et al., 1998).

Fertilization is very noteworthy practices for high yield and quality in fig (İrget et al., 2008).Very few research works have been carried out in world-wide on fig tree fertilization. Kabasakal (1983) studied seasonal changes of nutrient elements in fig fruits. Aksoy et al. (1987a) surveyed mineral nutrition of fig plantation of Germencik. Aksoy et al. (1987b), Anaç et al. (1987) and Aksoy et al. (1992) investigated the relations between mineral nutrition and fresh-dried fig fruits in Aegean region. Özer and Derici (1998) reported that there was a positive interaction between Ca and aflatoxin B_1 and a negative interaction between Cu and total aflatoxin, aflatoxin B_1. In addition, the samples showing fluorescence under UV light contained significantly higher levels of K, Na, and Ca. However, the samples which did not show fluorescence contained much more Cu than the other samples.

İrget et al. (2008) stated that basic NPK fertilization with additional 280g Ca /tree increased overall quality by reducing the number of sunscalded fruits and fruits with ostiole-end cracks. The results showed that the fertilizers applied significantly reduced the cull ratio and could alleviate the negative impact of drought, as well.

The aim of this research work to determine the effects of nitrogen application on the quality of dried fig fruits and aflatoxins. The study proved different nitrogen levels in soil may have effect on some parameters such as shoot and fruit quality, especially on aflatoxin formation inside the fruit.

MATERIALS and METHODS

The study was conducted in a slope fig orchard in Egrek village in Aydin between 2006 and 2008. In this study common fig variety, a 'Sarılop' tree nearly 15-20 years old (*Ficus carica* L. cv. Sarılop), which has the same plant canopy in a full yielding period was used. The tree vigour was almost similar, and the average canopy diameter was 6.90m.

In the first year of the study (2006), the orchard which no fertilization was applied was selected and some phenological and pomological characteristics of the trees were determined. In 2007 and 2008, different N rates were applied.

On the other hand, 450g P_2O_5/tree and 500g K_2SO_4/tree, were applied all the tree including control. As a P source triple superphosphate (TSP) (42-44%P_2O_5), as a K source K_2SO_4 (50%K_2O) and as N source $(NH4)_2SO_4$ (21%) were used. Fertilizers were applied to parallel line on all four sides of the tree at a depth of 10-15cm during the period in early February to late March.

The tested treatments are as follows:

(1) 100 g N/tree
(2) 200g N/tree
(3) 300g N/tree
(4) 400g N,/tree
(5) 500g N/tree
(6) Control

The experiment was designed as randomized blocks with three replicates, each replicate possessing two trees. In the first year of the study the leaf samples were taken during fruit maturation according to Kabasakal (1983).Partially shrivelled fig fruits fell onto the ground from the trees were collected separately and dried on drying trays. Cull fig fruits defined as defects in Turkish Dried Fig Standards TS 541 (Anonymous, 2006) and UN/ECE Dried Fig Standards (Anonymous, 2004) were removed and weighted. Total yield and yield components were determined and calculated at the end of the season in relation to the quality classification.

In the study, some important quality parameters about fig fruit were evaluated. Ostiole-end crack of the fruit was investigated in two ways. According to standards, if the ostiole-end crack is more than 1/3 of fruits length, those fruits are called sound. Sunlight damages less than 1/3 of fruit outer space was evaluated as good. Dried fig fruits of lower quality were defined as fruits that have cracks on and subject to solar damage and damage posed by the insects and birds. Dried fig fruits of lower quality are called cull figs that cannot be marketed for human consumption (Özbek, 1958). Ostiole width was measured with the a digital compass (BTS, 0-150mm) and the colour of the inner and outer parts of the dried fig fruits (Minolta, CR 400) and some shoot parameters (length, diameter, number of nods and length of inter nods) were determined with a digital compass (BTS, 0-150mm). The total soluble solids were measured with a hand-held refractometer (N.O.W., 0-32 %Brix) and titratable acidity (expressed as %citric acid) was determined by titration with 0.1 N NaOH. Aflatoxin analysis were made by high performance liquid chromatography (HPLC) (Shimadzu CLASS-VP V 613 SP1). ACE 5C 18 150 *4,6mm was used as colon.

Statistical analysis of data was made by using SPSS. Significant differences between the means were determined by Duncan's multiple range test.

RESULTS and DISCUSSION

Results of different nitrogen applications on some shoots parameters in 'Sarılop' fig trees is displayed on Table 1.

The highest shoot length, diameter, nod number and length of shoot inter nods were obtained from 500g N/tree application (Table 1). It was determined that there was statistically difference among nitrogen rates ($p<0.01$) and nitrogen rates*years interactions ($p<0.10$) on shoot length, while there was no difference between years. While the highest shoot length (85.19 mm) was obtained from 500 g nitrogen dosage, shoot lengths obtained from 100 g N (77.52 mm) and control applications (72.42 mm) followed it. The years ($p<0.01$) and nitrogen rates ($p<0.01$) had significant effect on shoot diameter. While the largest shoot diameter (11.63 mm) was obtained from 500 g nitrogen application, shoot diameter achieved from 100 g N application (11.15 mm) followed it.

Table 1. Shoot parameters (mm) obtained from tested treatments

Treatment	Shoot length (mm)	Shoot diameter (mm)	Number of nod (number)	Average internode Length
1. 100 g N	77.52 b	11.15 bc	6.36 c	15.47 ab
2. 200 g N	60.70 d	10.77 bc	6.03 d	13.08 c
3. 300 g N	71.52 bc	10.69 c	6.30 cd	14.55 b
4. 400 g N	70.58 c	10.89 bc	6.59 bc	15.19 ab
5. 500 g N	85.19 a	11.63 a	7.08 a	16.25 a
6. Control	72.42 bc	11.20 ab	6.75 b	14.67 b
Treatments (*p*)	0.000*	0.000*	0.000*	0.000*
Year 1	73.83 (2006)	11.26 a (2006)	6.82 a (2006)	14.90 (2006)
Year 2	71.99 (2007)	10.81 b (2007)	6.15 b (2007)	14.84 (2007)
Years (*p*)	ns	0.001*	0.000*	ns
Years x treatments (*p*)	0.058**	ns	0.003*	ns

*The mean difference is significant at the 0.01 level ($p<0.01$).

**The mean difference is significant at the 0.10 level ($p<0.10$).

The years, nitrogen rates ($p<0.01$) and years*nitrogen rates interactions had statistically significant effect ($p<0.01$) on the number of shoot nods. The highest number of shoot nods (7.08) were taken from 500g N applications, control group (6.75) followed this. Only nitrogen rates ($p<0.01$) had significant impact on the length of shoot inter nods. While the highest length of shoot inter nods (16.25 mm) was obtained from 500 g N application, 15.47 mm length was obtained from 100 g nitrogen application. The highest shoot length (85.19 mm.), shoot diameter (11.63 mm.), number of shoot nods (7.08) and length of shoot inter nods (16.25 mm) were achieved from the fig trees which were received 500 g N. Aksoy et al. (1987a) reported similar results. Considering all the shoot parameters, very little development was obtained in 2007 compare with 2006. This issue would be explained with drought climate conditions occurred in 2007.

Results of different N applications on some important quality parameters in 'Sarılop' fig trees are given at Table 2.

Taking cognizance of the total dried fig yields of each fig tree, it was obtained highest dried fig fruit yield (31770 g) from 100 g nitrogen and 500 g nitrogen application followed it (27525 g). Aydın and Izmir regions which are the most important dried fig production areas had heavy drought in 2007. It may be explained that dried figs showed lower quality and fruits subject to excessive sunlight. Hernandez et al. (1994) reported that nitrogen rates positively affect total soluble solids of fruits in only The ratio of severely sunscalded (sunburn damage) fruits in the 'Sarilop' cultivar grown under the Aegean Region conditions were reported range from 0.0% to 47.2% in 1992 and from 2.7% to 59.4% in 1993 (Aksoy, 1994).

Ostiole-end cracks and sunscald are leading defects in fig fruit quality. Ostiole-end crack has not been fully investigated in fig fruits yet, however, the previous studies based on observations and surveys display that ostiole-end cracking in a fig fruit was linked with variety, climatic conditions, soil properties (lime and available Ca content) and nutritional status, especially Ca (Aksoy et al., 1987b). The actual mechanism of sunscald needs further investigations as it is about fruit cracking. The results of surveys and on-going research display significant effect on soil properties and aspect (light intensity) on sunscald. In this respect, soil available potassium content seems to be effective on sunscald incidence, and K applications prevented or reduced the defect. Irget et al. (2008) explained that application of NPK enhanced fruit K content significantly, whereas, an addition to Ca to NPK decreased fruit K levels.

Table 2. Dried fig fruit (g/tree) obtained from different quality parameter tested treatments

Treatment	Sound	Sunscalded	Ostiole-end cracks	Cull figs	Total yield
1. 100 g N	16735	4504 b	7525	3006	31770
2. 200 g N	12596	3517 b	6403	1395	23911
3. 300 g N	12714	4942 ab	5340	1752	24748
4. 400 g N	11450	4484 b	3171	1314	20419
5. 500 g N	13649	7230 a	4679	1967	27525
6. Control	8354	4904 ab	2299	1110	16667
Treatments (*p*)	ns	0.084**	ns	ns	ns
Year 1	14084.72 (2006)	1472.33 b (2006)	7713.06 a (2006)	1566.11 (2006) 1949.17 (2007)	24836.22 (2006)
Year 2	11082.28 (2007)	8389.28 a (2007)	2093.28 b (2007)	ns ns	23514.00 (2007)
Years (*p*)	ns	0.000*	0.000*		ns
Years x treatments (*p*)	ns	0.095**	ns		ns

*The mean difference is significant at the 0.10 level (p<0.01).

**The mean difference is significant at the 0.10 level (p<0.10).

It wasn't defined statistically significant effect of years, nitrogen rates and years*nitrogen rates interactions on sound, ostiole-end cracks, cull and total yield of dried figs while it was only determined years (p<0.01), nitrogen rates (p<0.10), years*nitrogen rates interactions (p<0.10) had significant effect on sunscalded dried figs. The highest sunscalded dried figs (7230 g) were taken from 500 g nitrogen application. 300g N and control applications followed it. The most remarkable point is that while the degree of sunscalded and cull figs in 2007 (when drought conditions prevailed) was much more than 2006 (Table 2).

The effect of different nitrogen applications on the ostiole width and the colour of inner and outer parts of dried fig fruit colours are given in Table 3 and 4.

It has been indicated that ostiole width which causes access of insects and diseases is blocked by the effects of calcium (Aksoy et al., 1987a). Moreover, Irget et al. (1998) reported that $Ca(NO_3)_2$ and KNO_3 applications resulted in narrowing the ostiole width. Brightness, flexibility, softness, cracking and sugar content are accepted as essential parameters in terms of quality and taste in fig. Aksoy et al. (1991) stated iron, zinc and copper had an effect on fruit colour; iron and copper increase darkness. And zinc affects colour of the fig fruit .There wasn't identified no relations between nitrogen nutrition those quality parameters. Ferguson et al. (1990) suggested that breeding efforts should focus on the common type 'Calimyrna' for developing narrower ostiol end.

Table 3. The effects of different nitrogen applications on ostiole width and the colour of inner and outer (skin) parts of dried fig fruits

Treatment	Ostiole width (mm)	Colour L (inner)	Colour L (outer)	Colour a (inner)	Colour a (outer)	Colour b (inner)	Colour b (outer)
1. 100 g N	5.16	38.45	58.85	8.52	5.78	17.41	23.13
2. 200 g N	5.54	37.33	59.00	7.88	6.59	16.78	23.87
3. 300 g N	5.35	38.00	58.48	8.06	7.10	16.91	24.54
4. 400 g N	5.01	37.22	56.88	8.78	6.57	17.02	23.64
5. 500 g N	4.34	38.39	57.85	7.81	6.37	17.53	23.96
6. Control	5.49	37.96	57.64	8.69	7.10	16.56	24.30
Years							
2006	4.35	43.07	56.84	7.44	5.92	18.21	22.42
2007	5.50	32.71	59.39	9.13	7.25	15.85	25.40

Table 4. The correlation coefficients between ostiole width, the colour of inner and outer parts of dried fruits and factors

Factors	Ostiole width (mm)	Colour L (inner)	Colur L (outer)	Colour a (inner)	Colour a (outer)	Colour b (inner)	Colour b (outer)
Years	0.385**	-0.449**	0.251*	0.447*	0.443*	-0.375*	0.665**
Nitrogen dosages	-0.082	0.000	-0.107	0.035	0.176	-0.030	0.113

* Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

There was a positive correlation between ostiole width and years (r=0.385**). In 2007, when drought conditions prevailed, ostiole width was found larger than 2006. But there wasn't any correlation between nitrogen rates and ostiole width. By the way, despite the fact that there was correlation between years and all colour parameters, there wasn't any correlation between nitrogen rates and all colour parameters (Table 4).

The effects of different nitrogen applications on total soluble solids and acidity of dried figs were displayed and evaluated in Table 5.

The highest rate of total soluble solids was obtained from control group, 100 g, 400 g nitrogen applications and control group (56.33%). The lowest one was obtained from 200g application (53.00%). In addition, the highest acidity was determined from 500 g nitrogen application (0.88%) (Table 5).

The influence of various nitrogen sources on aflatoxin production in different species has been studied by several researchers. The possibility to use inorganic nitrogen for the production of higher yields of aflatoxin apparently depends on the strain of the fungus used and/or the composition of the nutrient solution.

Table 5. Effects of different nitrogen applications on dried fig fruit total soluble solids and acidity

Treatment	Total soluble solids (%)	Acidity (%)
1. 100 g N	56.33	0.65
2. 200 g N	53.00	0.61
3. 300 g N	54.33	0.75
4. 400 g N	56.33	0.63
5. 500 g N	55.33	0.88
6. Control	56.33	0.66
Years (Time)		
2006	55.28	0.70
2007	55.28	0.70

N nutrition, in combination with other agricultural practices, is reported to have a positive effect in reducing *A. flavus* group infections and aflatoxin contamination in corn when other environmental or biological stresses are not extreme. In contrary data from low N or late N treatments indicate that N may influence aflatoxin contamination at harvest. Significant differences are found in aflatoxin concentration due to nutrition. The result suggests that aflatoxin contamination can be related to inadequate irrigation, high population and/or extreme N deficiency. The late applications or large amounts of N or excessive fertilization with N, P and K also resulted in elevated concentrations (Wilson and Walker, 1981).

Jones and Duncan (1981) investigated the effects of N fertilization, planting date and harvest date on aflatoxin contamination of inoculated field corn. Regardless of the isolate used, less aflatoxin B_1 was detected in treatments receiving higher rate of nitrogen (145. 7 kg/ha) than in treatments receiving lower rate (11.2 kg/ha). Low nitrogen plants had 2.4 times more aflatoxin of B_1 than high nitrogen plants when results were averaged across cultivar, planting date and isolate. Jones and Duncan (1981) suggested that inadequate nitrogen fertilization alters the nutritional status of pre-harvest corn and makes it a better substrate for aflatoxin production.

Özer and Derici (1998), however, determined significant relation between the level of N in dried fig fruit and aflatoxin B_2 and total aflatoxin. According to the researches results can be attributed to the effect of N increasing the water content in the plant cell, causing turgidity in fruit and thus enhancing the growth rate of the pathogen. By increasing the water content N also extends the drying period and increases the risk of contamination. High levels of N cause colour deterioration in dried fig fruits and according to Gül (1990) there is a relationship between darker fruit colour and aflatoxin contamination of dried figs, which supports the correlation between N and aflatoxin levels.

It was found that as average in all applications, aflatoxin B_1, B_2, G_1, G_2 were 0.16, 0.14, 0.17 and 0.14 ppb, respectively. Those measures are very inconsiderable for export limits and market standards. And there wasn't any correlation between aflatoxin parameters and all nitrogen rates and years.

As a conclusion, it has been aimed to determine the effects of different nitrogen applications on some morphological, dried fruit quality parameters and aflatoxin levels on ‘Sarılop’ dried fig cultivar.

While the highest shoot length (85.19mm) was obtained from 500 g nitrogen dosage, 100 g N (77.52mm), control applications (72.42mm) followed it. The largest shoot diameter (11.63 mm), the highest number of shoot nods (7.08) and the highest length of shoot inter nods (16.25 mm) were obtained from 500 g nitrogen application. Taking cognizance of these results, up to 500g N/tree can be recommended to as optimum for dried fig according to findings of two years.

There wasn’t any significant effect of years, nitrogen rates and interactions on sound, cull, ostiole-end cracks and total yield of dried figs while it was only determined years ($p<0.01$), nitrogen rates ($p<0.10$), years*nitrogen rates interactions ($p<0.10$) had significant effect on sunscalded dried figs. The highest sunscalded dried figs (7230 g) were taken from 500 g nitrogen application. 300g N and control applications followed it. The most remarkable point is that while the proportion of sunscalded and cull figs in 2007 (when drought conditions prevailed) was much more than 2006.

In 2007 when drought conditions prevailed, ostiole width was found larger than 2006. Nevertheless, there wasn't any correlation between nitrogen rates and ostiole width. By the way, contrary to the fact that there was correlation between years and all colour parameters, it wasn't obtained any correlation between nitrogen rates and all colour parameters. And also there wasn't any correlation between acidity, total soluble solids and factors (years and nitrogen rates). Even though some significant correlations were found among some prominent parameters on dried fig, future studies should aim to exhibit mechanism of relationships among nitrogen rates, aflatoxin levels and other physiological indicators (ultraviolet radiation stress, free radicals, photosynthesis, nutrient assimilation etc.).

REFERENCES

Aksoy, U., D. Anaç, H. Hakerlerler and M. Düzbastılar. 1987a. Germencik yöresi Sarılop incir bahçelerinin beslenme durumu ve incelenen besin elementleri ile bazı verim kalite özellikleri arasındaki ilişkiler (in Turkish). Tariş Ar-ge, Bornova, Izmir. Proje no: Ar-Ge 006.

Aksoy, U., D. Anaç, N. Eryüce and T. Yoltaş. 1987b. Ege Bölgesinin incir bahçelerinin beslenme durumunun saptanması ve değerlendirilmesi (in Turkish). Ege Üniversitesi Ziraat Fakültesi Dergisi 24:2, 21-35.

Aksoy, U., D. Anaç and H.G. Seferoğlu. 1991. İncir bahçelerinde toprak özelliklerindeki farklılıkların sürgün gelişmesi ve meyve kalitesine etkileri (in Turkish). Toprak İlmi Derneği Sempozyumu, sözlü bildiri.

Aksoy, U., D. Anaç, and N. Gül. 1992. Sarılop incir çeşidinde yaş ve kuru meyve kalite kriterleri arasındaki etkileşimler (in Turkish). Türkiye I. Ulusal Bahçe Bitkileri Kongresi, cilt 1, 271-276.

Aksoy, U. 1994. Project on the improvement of fig production in the Aegean Region. TUBITAK Project no: TOAG 830. Izmir/Turkey.

Anaç, D., U. Aksoy, H. Hakerlerler and M. Düzbastılar. 1987. Küçük Menderes havzası incir bahçelerinin beslenme durumunun ve incelenen toprak ve yaprak besin elementleri ile bazı verim ve kalite özellikleri arası ilişkiler (in Turkish). Tariş Ar-Ge Müd., Bornova, Izmir, Proje No: Ar-Ge 4.

Anonymous. 2004. UN/ECE Standard DF-14 concerning the marketing and commercial quality control of dried figs. Geneva.

Anonymous.2006. Dried Figs. TS 541. Turkish Standards Institute, Ankara.

Bülbül, S., H. Atıl and S. Hepaksoy. 1998. A general study of commercial dried fig production in the Big Meander Valley of Turkey. Proc. 1st IS on Fig. Ed. U. Aksoy, L. Ferguson, S. Hepaksoy. Acta Hort. 480, ISHS 1998.

Ferguson, L., T.J. Michailides and H.H. Shorey. 1990. The California fig industry, Horticultural Reviews, p.409-490.

Gül, N. 1992. Sarılop incir çeşidinde bazı kuru meyve nitelikleri ile aflatoksin ilişkisi üzerinde araştırmalar (in Turkish). Yüksek Lisans Tezi, E.Ü. Fen Bilimleri Enstitüsü, Bahçe Bitkileri ABD.

Hernandez F.B.T., J.C. Modesto, M.A. Suzuki, L.S. Corrêa and K. Reichardt. 1994. Effects of irrigation and nitrogen levels on qualitative and nutritional aspects of fig-trees *(Ficus carica* L.). Sci. agric. (Piracicaba, Braz.) vol.51 no.2.

İrget, M., Ş. Aydın, M. Oktay, M. Tutam, U. Aksoy and M. Nalbant. 1998. İncirde potasyum nitrat ve kalsiyum nitrat gübrelerinin yapraktan uygulanmasının bazı besin maddeleri kapsamı ve meyve kalite özelliklerine etkisi (in Turkish). Ege Bölgesi 1. Tarım Kongresi 7-11 Eylül 1998, s: 414-428.

İrget, M.E., U. Aksoy, B. Okur, A.R. Ongun and M. Tepecik. 2008. Effect of calcium based fertilization on dried fig (*Ficus carica* L. cv. Sarılop) yield and quality. Sci. hortic. (article in press).

Jones, R.K. and H.E. Duncan. 1981. Effect of nitrogen fertilizer, planting date and harvest date on aflatoxin production in corn inoculated with *Aspergillus flavus*. Plant Disease 65, p. 741-744.

Kabasakal, A. 1983. Sarılop incir çeşidinde bazı mineral besin maddelerinin mevsimsel değişimi ve toprak-bitki-sürgün ve meyve gelişmesi ilişkileri üzerine araştırmalar (in Turkish). EÜZF Doktora Tezi.

Özbek, S. 1958. Factors affecting quality of dried figs (in Turkish). Journal of Ankara University, Faculty of Agriculture, p.140-153.

Özer, B. and B. Derici. 1998. A research on the relationship between aflatoxin and ochratoxin a formation and plant nutrients. Proc. 1st IS on Fig. Ed. U. Aksoy, L. Ferguson, S. Hepaksoy. Acta Hort. 480, ISHS 1998.

Wilson, D.M. and M.E. Walker. 1981. Calcium potential aflatoxin foe. Southeastern Peanut Farmer 19: 6B.