Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

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Asian Journal of Plant Sciences 6 (2): 294-297, 2007
ISSN 1682-3974

Effect of Fertilizer Rate on the Growth, Yield and Fruit Characteristics of Dried Apricot (cv. Hacihaliloglu)

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Abstract: Various Nitrogen (N), Phosphor (P) and Potassium (K) fertilization were investigated in apricot trees (cv. Hacihaliloglu) grown in Malatya, Turkey. High N application increased vegetative growth, yield and average fruit weight, but reduced total soluble solid content. K fertilization did not affect vegetative growth but resulted increase in total soluble solids and yield. High phosphor treatments showed yield increase while slowed vegetative growth. Based on yield, vegetative growth and fruit characteristics, the most effective fertilization rate for apricot (cv. Hacihaliloglu) was found to be 96-64-256 kg ha^{-1} NPK.

Key words: Apricot, fertilization, fruit quality, nitrogen, phosphor, potassium, yield

INTRODUCTION

Apricot is the most important fruit crop grown in Anatolia, with approximately 400-600 thousand tons of fresh fruit produced annually and Turkey is the biggest apricot producing country in the world (FAO, 2004). Malatya province at the East Anatolia region is the main apricot producing area not only in Turkey but also in the world. This province is well known with the best quality of dry apricots. Particularly, Hacihaliloglu is the most common and well adapted cultivar in this region (Asma, 2000).

There are few studies on fertilizer rate on the growth, yield and fruit characteristics of dried apricot (cv. Hacihaliloglu) in Malatya region. Also, studies on effect of K and P on these criteria were not emphasized enough in the apricot growing in the world. Potassium is absorbed by apricot trees in significant quantities (Huguet, 1988). There is not sufficient knowledge about the K and P effect on apricot growth and yield. Most of the researches has been done on this area was focused on N fertilization (Dimitrovski and Cevetkovic, 1981; Kotze and Villiers, 1991; Kotze and Joubert, 1992; Sud and Bhutani, 1994).

Although Turkey is the leading country in term of total apricot product, the yield per area in Turkey is low about 5.4 t ha^{-1}. The yield per are can be as high as 10-15 t ha^{-1} in the countries like Spain, Italy, France and USA (FAO, 2004). Problems in plant nutrients along with late spring frosts and brown rot (caused by *Moniliana laxa*) are the main obstacle on apricot production in Malatya region in Turkey. The objectives of our study were to determine the effects of N, P, K fertilizations on vegetative growth, yield and fruit characteristics of dried apricot (cv. Hacihaliloglu).

MATERIALS AND METHODS

This study was conducted over five growing seasons (years 1994 and 1998) on a 15-years-old apricot plantation cultivar Hacihaliloglu, at The Fruit Research Institute in Malatya Province, Turkey. Malatya Fruit Research Institute is located at 38°21' N latitude and 38°18' E longitude. It has 12.6°C annual average temperature and 495 mm annual precipitation. The average temperature and monthly precipitation in April-October are 19.9°C and 26 mm, respectively. The soil type is alluvial with a pH 7.90.

Hacihaliloglu is the most common cultivar grown in Malatya province. This cultivar was obtained by selection from that region in about 1900 in seedling apricot population. Hacihaliloglu has vigorous growth, susceptible to cold, drought and brown rot (Altindag *et al*., 2006). This cultivar has mid-size fruit with high Total Soluble Solids content (TSS) (Asma, 2000).

The potassium content of the soil at the beginning of the experiment, was 350 ppm (exchangeable K^+), P was 20 ppm, total salinity (mmhos cm^{-1}) was 0.27, pH was 8.3, $CaCO_3$ (%) was 38.4, organic material (%) was 2.0. Trees were spaced 8 m apart in the row with 8 m between

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rows. Trees were grafted on seedling apricot rootstocks. Orchard was regularly irrigated by furrow irrigation method. Weeds in the tree row were controlled manually by hoeing with two applications. The hand-thinning was not made. The experimental design included three blocks in a randomized complete block design, each experimental unit comprising four three.

Phosphorus (in the form of triple super phosphate) and potassium (in the form of potassium sulfate) were applied in autumn. Nitrogen (in form of ammonium sulfate) was applied in twice (March and June) before harvest. Fertilizer was applied in all combinations of N (N0 = 0; N_1 = 32 kg ha^{-1}, N_2 = 64 kg ha^{-1} and N_3 = 96 kg ha^{-1} of N), P (P_0 = 0; P_1 = 32 kg ha^{-1}, P_2 = 64 kg ha^{-1} and P_3 = 96 kg ha^{-1} of P_2O_5) and K (K_0 = 0; K_1 = 64 kg ha^{-1}, K_2 = 128 kg ha^{-1} and K_3 = 256 kg ha^{-1} of K_2O).

The fruits analyses were conducted on randomly-chosen 25 fruits per tree. The fruits and pits were weighed on scaled with 0.01 g. TSS was measured by a hand-held refractometer as% brix. The shoot length was measured from three spring per tree during fall. Fruit weight was measured after the harvest as table fruits in kg. The data from year 1997 were not included in the study as a light spring frost in April (-3.2°C) severely affected the yield. All the data from the experiment were subjected to the analyses of variance. The means and the standard deviations were calculated using a Microsoft Excel.

RESULTS

We have found differences on shoot growth between minimum and maximum doses of NPK applications. However, these differences were not statistically significant. Only, differences between P_2 and other doses found to be significant. Application of potassium has more effect on shoot growth than phosphorus and nitrogen applications (Table 1-4).

In general, N application resulted in increase in cumulative yield compare to P and K applications. P_2 doses were the best application for increase in cumulative yield. Cumulative yield was increased by additional N and P showed increase in total yield further.

We observed significant differences on yield (kg per tree) between minimum and maximum doses of NPK application according to years. The highest yield (kg per tree) was obtained from N_3 and P_2 doses (Table 1.) Present results showed that application of nitrogen and phosphorus are more limiting factor than application of potassium on total yield.

Table 1: Fruit weight, total soluble solids, yield and fruit size on various levels of NPK fertilization treatment

Treatment	Fruit weight (g)	Pit weight (g)	Soluble solid content (%)	Yield (kg/tree)	Cumulative yield	Shoot length (cm)	Fruit thickness (mm)	Fruit length (mm)	Fruit width (mm)
N_0	28.26±3.3	1.94±0.2	25.40±1.1	75.33±33.1	301.33	35.57±4.1	34.84±1.4	38.49±2.0	32.32±0.9
N_1	28.21±2.9	2.03±0.2	25.14±0.9	76.46±33.1	305.85	35.76±7.1	35.43±0.8	38.41±1.9	33.11±0.2
N_2	28.83±4.1	2.01±0.2	24.82±1.4	86.36±16.7	345.45	33.92±8.6	35.53±1.1	38.39±2.2	32.92±0.8
N_3	29.05±2.7	2.02±0.2	24.92±0.5	109.64±33.2	438.55	38.33±6.1	35.47±0.7	37.78±1.7	33.19±0.6
P_0	28.80±3.0	1.82±0.3	24.77±1.3	80.27±42.1	321.11	33.27±3.1	34.76±1.0	37.92±1.8	33.19±0.6
P_1	26.92±3.4	1.90±0.2	25.30±1.9	75.61±33.3	302.45	39.63±7.0	34.95±0.6	37.99±1.9	33.47±0.8
P_2	27.63±5.4	1.79±0.3	25.59±1.6	109.44±63.8	437.77	23.87±10.2	33.51±0.9	37.03±2.0	32.07±0.9
P_3	28.26±3.3	1.98±0.2	25.53±1.4	81.37±34.8	325.47	32.25±8.3	35.45±1.0	38.65±2.0	33.40±0.5
K_0	28.90±4.0	1.99±0.2	24.79±1.5	59.31±34.9	237.22	35.31±3.8	35.12±0.4	38.49±1.4	32.84±0.6
K_1	27.78±3.4	2.05±0.2	25.95±1.6	74.50±36.8	297.37	37.07±4.8	34.87±0.5	38.74±2.1	32.57±0.5
K_2	26.96±3.4	1.87±0.2	26.97±1.6	74.50±47.0	298.02	33.75±7.0	34.05±0.7	37.83±2.0	32.33±0.6
K_3	29.53±2.9	2.05±0.3	26.30±1.1	77.69±46.0	310.75	35.79±15.7	34.59±1.3	38.51±2.6	32.36±2.1

Table 2: Fruit weight, total soluble solids, yield and fruit size on various levels of N fertilization treatment

Treatment	Year	Fruit weight (g)	Pit weight (g)	Soluble solid content (%)	Yield (kg/tree)	Cumulative yield (kg)	Shoot length (cm)	Fruit thickness (mm)	Fruit length (mm)	Fruit width (mm)
	1994	23.88±1.6	1.55±0.1	25.43±0.4	59.33±6.9	59.33	32.20±5.9	33.32±0.8	36.05±0.7	31.69±0.5
	1995	31.27±1.4	2.17±0.2	26.65±0.5	33.75±4.6	93.08	42.07±5.5	33.73±0.5	40.57±0.4	31.35±0.5
N_0	1996	31.53±1.5	2.07±0.2	23.60±0.5	123.50±10.5	216.58	32.12±4.5	36.92±0.3	40.40±0.5	33.60±0.3
	1998	26.35±1.2	1.97±0.1	25.90±0.6	84.75±5.3	301.33	35.90±5.1	35.37±0.5	36.92±0.3	32.63±0.5
	1994	28.70±2.1	1.80±0.1	25.55±0.6	55.50±7.4	55.50	41.80±6.9	34.41±0.4	37.15±0.5	33.13±0.3
	1995	31.02±1.3	2.35±0.2	25.42±0.5	34.75±4.7	90.25	43.00±5.9	35.23±0.3	40.90±0.4	33.08±0.3
N_1	1996	29.80±1.2	2.10±0.1	23.68±0.6	118.50±8.9	208.75	32.50±4.7	36.54±0.5	39.50±0.6	33.36±0.4
	1998	23.31±0.8	1.87±0.1	25.90±0.5	97.10±5.6	305.85	25.75±3.3	35.54±0.7	36.10±0.5	32.88±0.4
	1994	24.82±1.3	1.75±0.1	23.53±0.5	78.25±7.3	78.25	22.50±5.5	34.22±0.5	36.87±0.6	32.45±0.4
	1995	33.20±1.1	2.37±0.1	25.93±0.4	63.50±6.4	141.75	44.92±6.1	36.59±0.6	41.12±0.5	34.09±0.5
N_2	1996	32.70±1.0	2.05±0.2	23.28±0.6	97.00±8.9	238.75	38.85±4.2	36.60±0.5	39.87±0.6	33.29±0.4
	1998	24.60±0.7	1.85±0.1	26.53±0.7	106.70±7.4	345.45	29.40±3.5	34.70±0.6	35.70±0.6	31.86±0.2
	1994	28.25±1.1	1.82±0.1	25.08±0.3	68.25±5.6	68.25	39.50±7.1	35.64±0.9	38.00±0.8	33.71±0.8
	1995	31.42±1.2	2.30±0.2	25.50±0.7	89.75±8.3	158.00	46.60±5.0	35.13±0.6	36.72±0.5	33.48±0.3
N_3	1996	31.50±1.0	2.17±0.2	24.09±0.3	154.75±10.8	312.75	37.75±6.7	36.47±0.5	40.47±0.6	33.20±0.5
	1998	25.03±1.1	1.77±0.1	25.00±0.5	125.80±7.5	438.55	29.47±3.9	34.62±0.5	35.90±0.5	32.37±0.4

Table 3: Fruit weight, total soluble solids, yield and fruit size on various levels of P fertilization treatment

Treatment	Year	Fruit weight (g)	Pit weight (g)	Soluble solid content (%)	Yield (kg/tree)	Cumulative yield (kg)	Shoot length (cm)	Fruit thickness (mm)	Fruit length (mm)	Fruit width (mm)
	1994	25.02±0.8	1.55±0.1	26.35±0.3	62.87±6.9	62.87	37.42±4.2	33.91±0.5	36.82±0.7	32.90±0.4
	1995	30.52±1.0	2.27±0.1	25.30±0.5	30.00±4.6	92.87	31.67±3.1	36.43±0.3	40.60±0.5	34.30±0.4
P_0	1996	25.40±0.9	1.77±0.2	22.82±0.4	145.62±12.9	238.49	29.14±4.8	34.54±0.4	38.42±0.4	32.00±0.3
	1998	22.27±0.9	1.67±0.1	24.62±0.5	82.62±6.3	321.11	34.83±3.5	34.13±0.4	35.85±0.5	32.11±0.3
	1994	25.05±1.0	1.65±0.1	27.07±0.4	62.90±5.8	62.90	50.55±4.8	34.16±0.4	36.60±0.4	34.18±0.3
	1995	32.02±1.3	2.25±0.1	26.07±0.3	29.75±8.3	92.65	35.42±4.4	35.63±0.3	40.75±0.6	34.22±0.4
P_1	1996	27.57±0.7	1.95±0.1	22.20±0.4	120.00±10.5	212.65	40.52±5.9	35.44±0.4	38.72±0.8	33.00±0.3
	1998	23.02±0.5	1.75±0.1	25.85±0.3	89.80±4.6	302.45	32.02±3.7	34.58±0.5	35.87±0.5	32.48±0.4
	1994	33.80±1.1	1.60±0.1	25.45±0.3	45.87±4.9	45.87	39.47±5.5	32.80±0.5	36.32±0.4	33.10±0.4
	1995	32.20±1.3	2.22±0.1	28.20±0.3	50.00±7.3	95.87	26.40±5.7	34.50±0.5	40.40±0.5	32.68±0.5
P_2	1996	22.10±0.6	1.68±0.1	24.75±0.4	195.00±11.8	290.87	13.17±2.2	32.40±0.6	36.42±0.4	30.90±0.4
	1998	22.40±0.5	1.65±0.1	23.95±0.4	146.90±8.1	437.77	16.42±3.0	34.33±0.4	34.97±0.6	31.58±0.3
	1994	26.50±0.9	1.90±0.1	27.30±0.2	31.00±2.9	31.00	45.92±5.5	33.87±0.7	37.52±0.6	33.00±0.6
	1995	35.05±1.0	2.38±0.1	25.90±0.5	71.75±6.6	102.75	23.82±2.9	36.70±0.5	41.85±0.7	34.26±0.2
P_3	1996	27.12±0.6	1.90±0.1	23.30±0.3	97.00±6.9	199.75	29.07±5.7	35.49±0.5	38.72±0.5	33.26±0.5
	1998	25.32±0.8	1.75±0.1	25.60±0.5	125.72±7.5	325.47	30.17±3.5	35.74±0.5	36.52±0.6	33.06±0.3

Table 4: Fruit weight, total soluble solids, yield and fruit size on various levels of K fertilization treatment

Treatment	Year	Fruit weight (g)	Pit weight (g)	Soluble solid content (%)	Yield (kg/tree)	Cumulative yield (kg)	Shoot length (cm)	Fruit thickness (mm)	Fruit length (mm)	Fruit width (mm)
	1994	27.97±0.5	1.80±0.1	24.32±0.4	44.00±5.3	44.00	37.67±6.0	35.03±0.4	37.25±0.5	33.00±0.3
	1995	35.12±1.2	2.30±0.2	25.87±0.5	16.75±3.1	60.75	36.75±5.9	35.60±0.5	40.20±0.6	33.70±0.4
K_0	1996	28.55±0.7	2.00±0.2	22.55±0.5	112.12±10.2	172.87	38.03±5.1	35.42±0.3	39.60±0.5	32.66±0.3
	1998	23.97±0.6	1.87±0.1	26.40±0.4	64.35±4.6	237.22	28.80±4.5	34.43±0.5	36.92±0.5	32.01±0.5
	1994	25.27±0.6	1.82±0.1	25.27±0.3	47.00±4.1	47.00	39.90±5.6	34.43±0.6	37.62±0.8	33.36±0.5
	1995	32.95±1.0	2.41±0.2	28.27±0.5	29.12±5.0	76.12	41.00±5.0	35.38±0.4	41.44±0.6	32.36±0.4
K_1	1996	28.57±0.8	2.03±0.2	23.85±0.4	110.75±8.6	186.87	38.57±6.2	35.36±0.5	39.87±0.6	32.44±0.5
	1998	24.32±0.6	1.95±0.2	26.40±0.3	110.50±7.4	297.37	28.82±5.3	34.32±0.5	36.04±0.6	32.12±0.5
	1994	27.30±0.9	1.70±0.1	25.25±0.5	42.50±5.5	42.50	41.77±3.3	34.46±0.5	36.62±0.7	33.39±0.6
	1995	32.07±1.1	2.25±0.2	28.32±0.3	18.25±2.9	60.75	39.35±6.6	33.10±0.4	40.82±0.7	31.99±0.5
K_2	1996	25.70±0.8	1.80±0.1	25.45±0.5	138.12±10.0	198.87	28.50±5.1	34.82±0.5	38.26±0.5	32.01±0.5
	1998	22.75±0.6	1.72±0.1	28.87±0.3	99.15±6.0	298.02	25.38±5.7	33.80±0.5	35.61±0.5	31.93±0.4
	1994	29.37±1.2	1.80±0.1	24.97±0.3	22.00±5.8	22.00	61.77±4.8	35.52±0.5	39.51±0.6	34.76±0.4
	1995	33.55±0.8	2.52±0.2	27.82±0.4	42.75±5.4	64.75	32.75±3.6	33.73±0.4	40.72±0.5	31.96±0.3
K_3	1996	29.74±0.8	2.02±0.2	25.60±0.5	127.50±12.4	192.25	28.57±6.0	36.09±0.6	39.70±0.6	33.33±0.6
	1998	25.47±0.9	1.85±0.2	26.70±0.4	118.50±9.2	310.75	20.05±4.9	33.03±0.5	34.12±0.5	28.98±0.3

Minimum and maximum doses of NPK applications among the years resulted in differences on the fruit weight. The biggest fruits obtained from N_3 and K_3 and the smallest fruit obtained from P_1 and K_2 doses. There were not statistically differences between these application doses. Fruit weight increased by additional nitrogen applications (Table 1 and 2).

We observed differences on pit weight among the years applied. Nitrogen and potassium applications had more effect on pit weight than phosphorus applications. Minimum and maximum doses of NPK applications among the years resulted in differences on the fruit dimensions. Present results indicated that the fruit dimensions are not affected by fertilization treatments.

Minimum and maximum doses of NPK applications resulted in differences on TSS content of fruits. Potassium application had more effect on TSS content than nitrogen and phosphorus applications. The highest TSS was seen on K_2 and K_3 doses (Table 1 and 4).

DISCUSSION

It has been reported that nitrogen applications on apricot trees has effect on tree growth, yield and fruit characteristics (Dimitrovski and Cevettkovic, 1981; Margarian *et al*., 1986; Kotze and Joubert, 1992; Sud and Bhutani, 1994; Bussi and Amiot, 1998; Bussi *et al*., 2003). Dimitrovski and Cevetkovic, 1981; Kotze and Viliers, 1991; Sud and Buthani (1994) reported that high nitrogen applications has no negative effect on amount of TSS content in the fruit. Bussi and Amiot (1998) emphasized that minimum and maximum nitrogen applications had no effect on TSS content but, potassium applications had increased TSS content of fruit. The same study also showed that fruit size was significantly affected by nitrogen application and no significant effect was observed by potassium fertilization. Bussi and Amiot (1998) reported that TSS content was increased by potassium application. It has been shown that N

application on apricot trees resulted in increase in fruit size while potassium application has no effect. The highest TSS content, total yield and vegetative growth was obtained from application of 150 kg N ha^{-1}. Trees with no N application caused smallest fruits (Bussi *et al.*, 2003).

Results from our study showed that application of nitrogen resulted in increase in vegetative growth and fruit size. One of the most desired fruit characteristics in dry apricot cultivars is high TSS content in the fruit. The highest TSS contents were obtained from K_2 and K_3 application. Minimum and maximum nitrogen applications had no effect on TSS content. On the other hand, TSS content was increased by potassium applications. These results were supported and in lined with the literature.

It has been known that potassium has no effect on total yield and fruit size. However, high nitrogen applications were effective on total yield (Bussi and Amiot, 1998; Bussi *et al*., 2003). Our study was also in agreement with these early researches. We have showed that increased nitrogen and phosphorus application resulted in increase in total yield and potassium has less effect on total yield than nitrogen and phosphorus applications. We have not found correlation between the fruit weight and tree yield. P_2 application resulted in highest total yield, results from the same application showed smallest fruits. Also, P_2 application resulted in the weakest shoot growth. However, this is supported by literature that there is a negative correlation between the vegetative and generative growth.

Result of the present study showed that the best treatments for yield, vegetative growth and fruit quality for Hacihaliloglu cultivar are N_3 with 96 kg ha^{-1}, P_2 with 64 kg ha^{-1} and K_3 with 256 kg ha^{-1}. Marinov (1983) reported 300: 160: 200 kg ha^{-1} NPK rate is sufficient for high yield, optimum growth and high fruit quality in apricot trees. Optimum NPK doses for Newcastle apricot cultivar was determined as 100: 80: 100 kg ha^{-1} $N:P_2O_5:K_2O$ (Bunea, 1985). Also, Bajwa and Misra (1972), in a similar study, showed that 450 g/tree N application resulted in desired response in Newcastle cultivar apricot trees. In other studies it has been showed that increasing N content from 100 to 200 kg ha^{-1} resulted in higher yield, bigger fruit without compromising fruit quality (Margarian *et al*., 1986; Watanable *et al*., 1990). These findings are supporting present results on NPK fertilization rate on Hacihaliloglu cultivar apricot.

ACKNOWLEDGMENTS

The authors are grateful to Dr. Sedat Serce, Mustafa Kemal University, for the critical reading and help during the preparation of the original manuscript. This research was supported by grants from Agriculture Ministry of Turkey Inonu University (TAGEM/IY/96/06/02/020).

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