Effect of nitrogen, phosphorus, potassium fertilizers and manure on growth and productivity of the peach cultivars Springtime and Redhaven

I. T. CHATZITHEODOROU[1], T. E. SOTIROPOULOS[1], G. I. MOUHTARIDOU[1], D. ALMALIOTIS[2]

[1]*N.AG.RE.F., Pomology Institute, Naoussa, Greece*
[2]*N.AG.RE.F., Soil Science Institute, Thermi-Thessaloniki, Greece*

ABSTRACT: The response of the peach cvs. Springtime and Redhaven to nitrogen, phosphorus, potassium fertilizers and manure is reported. The research was conducted during a period of 10 years. The following fertilizer combinations were used: control (no fertilization), N, P, K, NP, NK, PK, NPK, manure, N + manure, P + manure, K + manure, NP + manure, NK + manure, PK + manure, NPK + manure. The following measurements were performed: a) productivity (kg/tree); b) mean fruit weight (g); c) fruit number per tree; d) fruit setting (%); e) trunk circumference (cm), and f) shoot weight (kg) removed by pruning. It is concluded from the results that the two cvs. did not always respond to the various treatments in the same way. Application of N plus manure to peach trees of the cv. Springtime resulted in the highest productivity. The higher productivity of the cv. Redhaven was recorded in the treatments N and NPK. The lowest productivity, fruit number, total trunk circumference and shoot weight removed by pruning of both cvs. were recorded in the control and PK treatments in comparison with all the others. Fruit setting of the cv. Springtime was highest in the NP + manure treatment, followed by the PK + manure one. Fruit setting of the cv. Redhaven was higher in the PK + manure, NK + manure and K + manure treatments. Shoot weight that was removed by pruning was highest in the NK + manure treatment for the cv. Springtime, whereas for the cv. Redhaven it was highest in the N + manure treatment in comparison with the remaining ones.

Keywords: mineral fertilizers; manure; fruit set; fruit weight; *Prunus persica*; trunk circumference; yield; cultivars

Peach trees are grown on large areas in some regions of northern Greece. On fertile soils, N is often the only nutrient that needs to be supplied to peach trees on a regular basis. On less fertile soils, deficiencies of K, Mg, Mn, Fe, Zn and B may develop. Deficiencies of P, Ca, S and Cu are rarely seen (JOHNSON, URIU 1989; JOHNSON 1993). A nutrient survey in Greece indicated that zinc, manganese, and in some cases iron deficiencies are frequent in peach orchards (STYLIANIDIS, SYRGIANNIDIS 1995). Several reports showed that increases in the fruit set of cherries (WHITE 1968) and apricots (JACKSON 1970) could be obtained by various N treatments. Jonathan apple trees deficient in P showed retarded development of a reduced number of floral meristems (TAYLOR, GOUBRAN 1975). In peach, P applications increased flower formation, whereas N was found to reduce it (FUKUDA, KONDO 1957). Fruit yield and fruit weight of peach fruits increased with increasing rate of application up to 700 g K/tree (AWASTHI et al. 1998). SAENZ et al. (1997) proposed that N stimulated increases in peach yields were associated with extended fruit development period and increased fruit sink capacity. ARORA et al. (1999) concluded that tree height, trunk circumference, flowering intensity, fruit set, fruit weight and fruit yield were directly associated with leaf N content. Mineral nutrition is a pre-harvest factor that affects fruit quality and has to be performed very carefully, since peach quality cannot be improved, only maintained, after harvest (CRISOSTO et al. 1997).

The aim of the present research was to study the response of the peach cultivars Springtime and Redhaven to nitrogen, phosphorus and potassium fertilizers, manure, as well as some combinations of these nutrients. Because fertilization of peach trees exerts a significant effect on growth and productivity, the following measurements were accomplished: yield per tree, fruit weight, fruit number per tree, fruit set, trunk circumference and shoot weight removed by pruning.

MATERIALS AND METHODS

The research was conducted during a period of 10 years (from the 5th to the 14th year of the productive life of trees) in a peach (*Prunus persica* L. Batsch) orchard, on the farm of the Pomology Institute (Skydra area). The soil of the orchard was characterized as clay loam. The soil properties of the experimental orchard are presented in Table 1. Flood irrigation was applied. Its frequency was estimated by means of soil tensiometer readings.

The soil samples were air dried, crushed to pass a 2-mm screen and analyzed for pH at a 1:1 soil to water ratio, electrical conductivity in a 1:5 soil to water extract, texture (hydrometer method), $CaCO_3$ with volumetric

Table 1. Soil properties of the experimental orchard from a depth of 30–70 cm

Soil property	Mean value
Texture class	CL (clay loam)
pH (1:1 H_2O)	7.35
$CaCO_3$ (%)	1.22
Organic matter (%)	0.59
Electrical conductivity (1:5) (mS/cm)	0.96

calcimeter and organic matter content after wet oxidation (PAGE et al. 1982).

The experimental trees of the cvs. Springtime (early season) and Redhaven (mid-season) were grafted on wild seedlings, planted at distances 5 × 5 and trained as a typical vase shape. From the planting of the trees to the 7th year, nitrogen was applied at a half amount as ammonium sulphate and a half amount as ammonium nitrate. Since the 8th year nitrogen was applied only in the form of ammonium sulphate. Ammonium sulphate was applied 40 days before blooming and ammonium nitrate twice after leaf emergence. Phosphorus was applied during the 7th year in the form of 0-46-0 and for the remaining years in the form of 0-21-0. Potassium was applied in the form of 0-0-50. Phosphorus and potassium fertilizers as well as manure were applied at the beginning of winter. The following fertilizer combinations were used: control (no fertilization), N, P, K, NP, NK, PK, NPK, manure (cattle), N + manure, P + manure, K + manure, NP + manure, NK + manure, PK + manure, NPK + manure. The amounts of fertilizers that were applied each year are presented in Table 2. Chemical composition of manure was as follows: N 1.9% dry weight, P 0.7%, K 2%, Ca 1.3%, Mg 0.7%, Fe 5,000 g/t dry weight, Mn 40 g, Zn 8 g, B 14 g.

Fertilizer applications till the 5th year were performed at the projection of the foliage of the trees, while for the remaining years at the whole surface of the experimental blocks. In order to avoid nutrient deficiencies of the other nutrients, the following treatments were performed every 2 years. Boron was applied into the soil in the form of Solubor (20.5% B) at a quantity of 60 g/tree. Zinc was provided as $ZnSO_4$ and Mn as $MnSO_4$ by spraying the trees during winter at concentrations 0.25% and 3%, respectively. Magnesium was provided as $MgSO_4$ 7 H_20 by spraying the trees a month later after full bloom (1%). Iron was applied as Sequestrene 330 (10% Fe) at a quantity of 30 g/tree.

The following measurements were performed: a) yield (kg/tree); b) mean fruit weight (g); c) mean fruit number per tree; d) fruit set (%); e) trunk circumference (cm) and f) shoot weight (kg) removed by pruning.

The adopted experimental design was a randomized complete block with 5 replications of 16 treatments (fertilizer combinations) per cultivar. Differences between means were evaluated using Duncan's multiple range test at $P = 0.05$.

RESULTS AND DISCUSSION

The application of N plus manure to peach trees of the cv. Springtime resulted in the highest productivity of the trees (Table 3). On the contrary, control, P, K, and PK fertilization resulted in very low productivity. All fertilizer treatments (except PK) significantly increased productivity in comparison with the control. The highest productivity of trees of the cv. Redhaven was recorded in the treatments N and NPK but it was not significantly different from those of NP, NK, manure, PK + manure, and NPK + manure (Table 4). The lowest productivity was recorded in the treatments P, PK, and control. CRISOSTO et al. (1997) reported that nitrogen deficiency led to unproductive trees. In plants suffering from N deficiency a reduction in net photosynthesis and decline of elongation rates of leaves were observed (MARSCHNER 1995). Nitrogen fertilization stimulates peach yield by increasing the period for fruits to use assimilates (SAENZ et al. 1997). BALLINGER et al. (1966) reported that P appeared to have only a little beneficial effect on peach yield. Application up to 0.7 kg K_2O peach/tree resulted in an increase in yield and fruit quality (CUMMINGS 1973). Furthermore, AWASTHI et al. (1998) concluded that fruit yield of peach trees increased with increasing rate of application up to 700 g K/tree. Finally, ARORA et al. (1999) concluded that fruit yield was associated with leaf N content.

Mean fruit weight of the cv. Springtime was higher in the NP, NPK, NP + manure, and NPK + manure treat-

Table 2. Amounts of fertilizers that were applied to the trees from the first year of orchard establishment to the fourteenth year for the cvs. Springtime and Redhaven

Age of the trees	N (g/tree)	P_2O_5 (g/tree)	K_2O (g/tree)	Manure (kg/tree)
1	38	38	38	12
2	76	76	76	24
3	114	114	114	36
4	152	152	152	48
5	190	190	190	60
6	456	228	228	60
7	532	266	266	60
8–14	608	304	304	60

Table 3. Effect of N, P, K fertilizers and manure on yield (kg/tree), mean fruit weight (g), fruit number, fruit set (%), trunk circumference (cm) and shoot weight removed by pruning (kg) of the peach cv. Springtime during a period of 10 years

Fertilization	Yield (kg/tree)	Mean fruit weight (g)	Fruit number	Fruit set (%)	Trunk circumference (cm)	Shoot weight (kg) removed by pruning
Control	45.5 h*	88.2 ab	225 l	55 c	27.23 f	8.4 hi
N	106.5 a	87.5 ab	636 b	60 bc	52.16 a	34.8 ab
P	71.7 fg	81.9 b	394 i	61 abc	33.40 e	12.0 h
K	63.1 g	83.1 ab	310 j	59 bc	31.91 ef	10.5 hi
NP	90.5 cde	90.8 a	537 de	60 bc	44.39 bcd	30.8 c
NK	83.0 de	90.2 ab	443 h	64 abc	46.46 abc	23.0 e
PK	51.0 h	90.5 ab	273 k	63 abc	26.53 f	7.7 i
NPK	84.4 de	91.3 a	492 fg	59 bc	43.14 bcd	26.9 d
Manure	80.2 ef	87.2 ab	513 ef	64 abc	39.87 d	17.8 g
N + manure	109.2 a	86.7 ab	712 a	61 bc	52.33 a	35.6 ab
P + manure	93.5 bcd	87.3 ab	582 c	65 abc	39.44 d	17.2 g
K + manure	86.1 de	87.9 ab	479 g	63 abc	39.70 d	18.4 fg
NP + manure	102.8 ab	91.5 a	554 cd	71 a	47.75 ab	36.9 ab
NK + manure	104.6 ab	89.0 ab	628 d	64 abc	50.81 a	37.6 a
PK + manure	99.1 abc	87.0 ab	561 cd	67 ab	41.26 cd	21.5 ef
NPK + manure	93.1 bcd	90.9 a	576 c	63 abc	49.06 ab	33.3 bc

*Means followed by the same letter in the same column are not significantly different (Duncan's multiple range test, $P = 0.05$)

ments in comparison with the P one (Table 3). Mean fruit weight of the cv. Redhaven was highest in the NPK + manure treatment (Table 4). CRISOSTO et al. (1997) reported that N deficient peach trees produced small fruits. RADER et al. (1985) pointed out that N fertilization resulted in an increase of peach size. Furthermore, ARORA et al. (1999) concluded that fruit weight was associated with leaf N content. The highest yield with largest fruits was recorded on peach trees fertilized with 1 kg N and 1.2 kg each of P and K. Furthermore, fruit weight of peach trees increased with increasing rate of application up to 700 g K/tree (AWASTHI et al. 1998).

Fruit set of the cv. Springtime was highest in the NP + manure treatment, followed by the PK + manure one

Table 4. Effect of N, P, K fertilizers and manure on yield (kg/tree), mean fruit weight (g), fruit number, fruit set (%), trunk circumference (cm) and shoot weight removed by pruning (kg) of the peach cv. Redhaven during a period of 10 years

Fertilization	Yield (kg/tree)	Mean fruit weight (g)	Fruit number	Fruit set (%)	Trunk circumference (cm)	Shoot weight (kg) removed by pruning
Control	75.8 h*	157.32 ab	208 i	48 d	26.15 h	8.6 h
N	158.7 a	151.02 b	641 d	57 abcd	45.44 ab	24.2 de
P	82.0 h	150.76 b	323 g	50 cd	29.28 fgh	12.4 g
K	104.1 fg	150.82 b	241 h	56 abcd	26.73 gh	10.6 gh
NP	155.0 ab	150.71 b	546 e	59 abc	38.00 cde	22.5 e
NK	149.5 abc	158.38 ab	634 d	56 abcd	40.39 bcd	21.8 e
PK	91.3 gh	157.11 ab	254 h	47 d	24.74 h	7.9 h
NPK	157.9 a	154.55 ab	723 b	52 abcd	40.30 bcd	26.8 cd
Manure	137.4 abcd	155.75 ab	545 e	50 bcd	35.18 def	17.4 f
N + manure	130.2 bcde	155.48 ab	673 c	60 ab	49.91 a	36.1 a
P + manure	129.0 cdef	154.15 ab	545 e	57 abcd	37.14 de	18.0 f
K + manure	117.8 def	156.40 ab	493 f	61 a	32.73 efg	15.9 f
NP + manure	112.1 efg	154.75 ab	804 a	55 abcd	48.30 a	32.5 b
NK + manure	104.9 fg	152.24 ab	832 a	61 a	44.36 abc	30.0 bc
PK + manure	139.4 abcd	155.15 ab	629 d	62 a	34.59 def	22.0 e
NPK + manure	136.0 abcde	159.96 a	627 d	56 abcd	40.79 bcd	28.3 c

*Means followed by the same letter in the same column are not significantly different (Duncan's multiple range test, $P = 0.05$)

(Table 3). The lowest fruit set for both cvs. was recorded in the control in comparison with the remaining treatments (Tables 3, 4). Fruit set of the cv. Redhaven was higher in the PK + manure, NK + manure, and K + manure treatments (Table 4). The effect of mineral nutrition in the process of fruit set is well documented. Increases in fruit set can be obtained by N fertilization, while P application enhanced bud burst (KHAN et al. 2000). Furthermore, increases in fruit set of cherries (WHITE 1968) and apricots (JACKSON 1970) can be obtained by various N treatments. In peach, P applications increased flower formation (FUKUDA, KONDO 1957). KHAN et al. (2000) concluded that the highest fruit set was recorded on peach trees fertilized with 1 kg N and 1.2 kg each of P and K. The highest fruit number per tree of the cv. Springtime was recorded in the N + manure treatment followed by the N treatment. On the contrary, very low fruit numbers were determined in the control and PK treatments (Table 3). The lowest fruit number per tree of the cv. Redhaven was found out in the control in comparison with the remaining treatments (Table 4).

Trunk circumference of the cv. Springtime was higher in the N + manure, N and NK + manure treatments in comparison with the remaining ones (Table 3). The lowest trunk circumference values were measured in the PK and control treatments for both cvs. (Tables 3, 4). Total trunk circumference of the cv. Redhaven was higher in the N + manure, NP + manure, N, and NK + manure treatments in comparison with the remaining ones (Table 4). Trunk circumference was found to be directly associated with leaf N content (ARORA et al. 1999).

Shoot weight (kg) of the cv. Springtime that was removed by pruning was highest in the NK + manure treatment (Table 3). The lowest shoot weight removed by pruning for both cvs. was measured in the control and PK treatments in comparison with the remaining ones (Tables 3, 4). Shoot weight of the cv. Redhaven that was removed by pruning was highest in the N + manure treatment in comparison with the remaining ones. Tree height was directly associated with leaf N content as reported by ARORA et al. (1999). In the peach cv. Fidelia, the number of formed shoots depended on N availability in the period following the bud break. Furthermore, the proportion of shoots that showed the second or third development stage depended on N availability at the beginning of that stage (LOBIT et al. 2001).

It is concluded from the results that the two cvs. did not always respond to the various fertilizer treatments in the same way, indicating a genotypic effect. Application of manure into the soil had a positive effect on all tested parameters of growth and productivity. Thus, manure use by growers in combination with inorganic fertilizers can be recommended as a useful fertilization practice in order to improve productivity of their peach orchards.

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Vliv hnojení dusíkem, fosforem, draslíkem a hnojem na růst a výnosy odrůd broskvoní Springtime a Redhaven

ABSTRAKT: Příspěvek se zabývá desetiletým studiem vlivu hnojení dusíkem, fosforem, draslíkem a chlévským hnojem na odrůdy broskvoní Springtime a Redhaven. V pokusu byly sledovány následující varianty hnojení: kontrola (bez hnojení), N, P, K, NP, NK, PK, NPK, hnůj, N + hnůj, P + hnůj, K + hnůj, NP + hnůj, NK + hnůj, PK + hnůj, NPK + hnůj. Předmětem hodnocení byly následující charakteristiky: a) výnos (kg/strom), b) průměrná hmotnost plodů (g), c) počet plodů na stromě, d) násada plodů, e) obvod kmene (cm) a f) hmotnost řezem odstraněných větví. Z výsledků vyplývá závěr, že obě odrůdy nereagovaly vždy na různé způsoby hnojení stejně. U odrůdy broskvoně Springtime byl dosažen největší výnos ve variantě hnojené N + hnůj. Naproti tomu odrůda Redhaven přinesla největší výnosy ve variantách hnojených N a NPK. U obou odrůd však byly výnosy, počty plodů, obvody kmenů a hmotnost řezem odstraněných větví nejnižší u kontroly a ve variantě hnojené PK. Násada plodů u odrůdy Springtime byla nejvyšší ve variantě NP + hnůj, následovaná variantou PK + hnůj. Násada plodů u odrůdy Redhaven byla nejvyšší ve variantě PK + hnůj, za níž následovaly varianty NK + hnůj a K + hnůj. Hmotnost větví odstraněných řezem byla v případě odrůdy Springtime nejvyšší ve variantě NK + hnůj, zatímco u odrůdy Redhaven to bylo ve variantě N + hnůj.

Klíčová slova: minerální hnojiva; hnůj; násada plodů; hmotnost plodů; *Prunus persica*; obvod kmene; výnos; odrůdy

Corresponding author:

Dr. THOMAS E. SOTIROPOULOS, N.AG.RE.F., Pomology Institute, P.O. Box 122, 59200 Naoussa, Greece
tel.: + 302 332 041 548, fax: + 302 332 041 178, e-mail: thosotir@alfanet.gr