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# Effect of fertigation on growth, yield and quality of almond under Kashmir conditions

**Dinesh Kumar* and D.B. Singh**
ICAR- Central Institute of Temperate Horticulture, Srinagar 190 025, Jammu & Kashmir

## ABSTRACT

**An experiment was conducted for three consecutive years during 2011-12 to 2013-14 with an objective to improve growth, yield and quality of almond by fertigation. There were seven fertigation treatments laid out in randomised block design with three replications. The results revealed maximum plant height (3.67 m), TCSA of main trunk (101.22 cm$^2$), primary, secondary and tertiary branches (20.51 cm$^2$, 6.66 cm$^2$ and 1.97 cm$^2$), canopy volume (8.21m$^3$), and nut yield (4.94 kg/tree and 5.48 t/ha), leaf nitrogen and potassium content (2.39 % N and 1.41%K) with 75% RDF through fertigation (split application of N : K in the ratio of 2/3N : 1/3K at nut set to nut development and 1/3N : 2/3K at kernel filling to maturation stage(T-4). The highest fruit number (2208/tree), however, was recorded with 100% RDF through fertigation (T2). The maximum nut weight and size (2.29 g and 36.51 × 21.45 mm), kernel weight and size (1.48 g and 24.71 × 14.59 mm) were recorded with 50% RDF through fertigation ($T_5$) treatment of almond variety Waris under Kashmir valley condition.**

**Key words :** *Prunus dulcis*, temperature, stone fruit, soluble fertilizers.

## INTRODUCTION

Almond (*Prunus dulcis*) is one of the important nut crops of temperate region of India, mainly grown in Kashmir valley. In India, it is grown over an area of 12,000 hectares with an annual production of 7,000 tonnes (NHB, 12). The kernels are concentrated sources of energy with a significant share of fat, protein, and fibre. Commercial almond production in India is low considering the demand and economical potential. Irrigation and fertilizers are the most important inputs which directly affect the plant growth, fruit yield and quality. Application of fertilizers through drip irrigation is the most effective way for supplying nutrients to the plant and increases fertilizer use efficiency. In general, most of the farmers apply the fertilizers in single soil application during dormant season and no fertilizer is applied during vegetative, flowering, and fruit growth stages, thus the effectiveness of the applied fertilizers is reduced considerably. Drip irrigation plays a major role in productivity enhancement in almond (Khan *et al*.6). Reddy *et al.* (15) obtained significantly higher yield, fruit size, weight and fertilizer use efficiency in banana with fertigation compared to soil application in banana. Application of nutrients through fertigation improves yield and quality in fruit crops as reported by Chauhan and Chandel (4) in kiwifruit, Ahmad *et al.* (1) in cherry, Raina *et al.* (13) in apricot, Banyal *et al*. (2) in peaches, Rao and Subramanyam (14) in pomegranate, Kumar and Pandey (7) in banana, Singh *et al*. (18) in apple and Shirgure *et al*. (17) in Nagpur mandarin.

Under drip irrigation, only a portion of soil volume around each plant is wetted and thus traditional methods of fertilizers application are less effective. The limited root zone and reduced amount of mineralization in restricted wetted zone are the main reason for the reduced nutrient availability to the plants (Magen, 9). One of the major advantages of fertigation is that it permits timely application of nutrients directly to root zone, reduces leaching losses, and increases the fertilizers use efficiency (Rolston *et al*. 16). The nutrient requirement of almond crop through fertigation as per the crop growth stage for better crop production. The systematic information is not available in almond especially water and nutrient management. Therefore, the present investigation was aimed to increase production and potential of almond by nitrogen and potassium fertigation in north western Himalayan region of India.

## MATERIALS AND METHODS

A field experiment was conducted at ICAR-Central Institute of Temperate Horticulture (ICAR), Srinagar, Jammu and Kashmir, during 2011-12 to 2013-14 for consecutive three years. The research farm at Srinagar located at a latitude of 34º05'N and longitude of 74º50'E with an altitude of 1640 m above MSL. The soils of this experimental field are silty loam (39.60% sand, 24.0% silt, and 36.40%

*Corresponding authors' Present address: ICAR- Central Institute for Subtropical Horticulture, Lucknow, Email: dkches@rediffmail.com

clay) with medium to low soil fertility status. The experimental farm falls under temperate region having cold conditions from November to February and three year mean maximum and minimum temperature of Srinagar climate indicated that the maximum is $31^0$C in August and the minimum is $2.2^0$C in December. The average annual precipitation was 650 mm distributed erratically throughout the year during the course of investigation.

The almond grafted on seedling rootstocks were planted in prefilled pits of 90 cm × 90 cm × 90 cm dimension during November,2002 at 3m × 3m spacing. The recommended dose of fertilizers were applied as per the package of practices for the region. The full quantity of phosphorus in plant basin has been applied 15 days before flowering in almond. The nitrogen and potassium doses were applied through fertigation as per treatment. There were seven treatments- $T_1$-100% Recommended Dose of Fertilizers(Soil application), $T_2$-100% RDF through fertigation, $T_3$-75% RDF through fertigation, $T_4$-75% RDF through fertigation (split application of N : K in the ratio of 2/3N : 1/3K at nut set to nut development and 1/3N : 2/3K at kernel filling to maturation stage), $T_5$-50% RDF through fertigation,$T_6$-50% RDF through fertigation (split application of N : Kin the ratio of 2/3N : 1/3K at nut set to nut development and 1/3N : 2/3K at kernel filling to maturation stage) and $T_7$-Control (without fertilizer). The experiment was laid out in randomized block design with four replications and two plants were taken in each replication.

Water soluble fertilizers like urea as a source of nitrogen and muriate of potash as potassium were injected through drip irrigation system at weekly intervals as per crop nutrient requirement in almond. The concentration of nutrient solution passing through irrigation water was around 1.0–1.5 percent. A separate laterals line (16 mm) was laid for each treatment and four emitters of 4 litre per hour capacity with pressure compensated connected with 12 mm lateral were placed equidistance in east-west north-south direction at 50% distance of canopy radius. The diameter of lateral pipe was 16 mm connected with sub main pipe. The irrigation was applied throughout the growing season (till initiation of leaf fall) based on pan evaporation (80%) with the following formula:

Water requirement (litre/plant/day)= (DE × CF × AA × PC) / IE

Where DE is daily pan evaporation from class-A pan (mm); CF is crop factor; AA is area allotted to each plant ($m^2$); PC is percentage of canopy (leaf coverage in relation to area allowed to plant); and IE is irrigation efficiency (0.9). The other cultural practices including weed, pest, and diseases management were followed uniformly as per recommended package of practices.

The observations on canopy volume (CV) were estimated for each individual tree using a geometrical model referred to as the "contour method" $CV = [(1/4)\pi abh)/(m(x) + m(y) + 1)]$. The dimensions *a* and *b* were measured the width of tree at the base of the canopy perpendicular and parallel to the tree row orientation, respectively. The height of the canopy (h) was measured from the lowest branch to the apex. The functions $m(x)$ and $m(y)$ were derived to accommodate the contour of the tree (Wright *et al.*20). CV measurements were made after harvest in October 2011,2012 and 2013. Tree trunk girth was recorded before the execution and at the end of experiment during the year of study. A ring was made with red paint at a height of 15cm above the ground level in each selected tree to record the trunk girth from the same point each year. The trunk cross-sectional area (TCSA) of tree was calculated by using formula $TCSA = Girth^2/4\pi$. Fruit was harvested at maturity, hulled, and dried and nut weight in gram and yield per tree was recorded in kilogram. The nut and kernel size was determined by observing the length and diameter was measured by Vernier calipers and expressed in millimeter.

Leaf samples were collected for leaf nutrient analysis as per procedure out lined by Chapman (3). For macronutrient except *N* estimation, well-ground leaf tissue was digested in diacid mixture containing $HNO_3$ and $HClO_4$ in 9:4 ratio for *P*, *K* by using ammonium molybdate: ammonium meta vanadate using double beam UV-Visspectro photometer (ECIL India) and the potassium was determined by using flame photometer (Jackson,5). For leaf *N* estimation, a known weight of samples was digested with $H_2SO_4$ using 10:1$K_2SO_4$ and $CuSO_4$ as digestion mixture and digested at $390^0$C until clear digestion was obtained. Digested samples were subjected to distillation with 40% NaOH and liberated ammonia was collected $H_3BO_3$using mixed indicator. Finally liberated ammonia was titrated against 0.1N $H_2SO_4$ and *N* content in the leaves was expressed in percentage. The data were analyzed statistically as per Steel and Torrie (19) for interpretation of results and drawing conclusions.

## RESULTS AND DISCUSSION

Vegetative growth such as plant height, cross sectional area of main trunk, primary, secondary and tertiary branches and canopy volume as influenced by fertigation technique in almond (Table 1). Maximum plant height (3.67 m), cross sectional area of main trunk (101.22 $cm^2$), primary (20.51

**Table 1.** Vegetative growth as influenced by fertigation in almond cv. Waris.

| Treatment | Plant height (m) | Cross Sectional Area ($cm^2$) | | | | Canopy volume ($m^3$) |
|---|---|---|---|---|---|---|
| | | Main trunk | Primary branch | Secondary branch | Tertiary branch | |
| $T_1$ | 3.50 | 91.95 | 19.64 | 6.25 | 1.76 | 7.29 |
| $T_2$ | 3.67 | 101.22 | 20.51 | 6.66 | 1.97 | 8.21 |
| $T_3$ | 3.35 | 96.49 | 18.08 | 5.89 | 1.77 | 6.41 |
| $T_4$ | 3.59 | 99.82 | 20.35 | 6.61 | 1.85 | 7.87 |
| $T_5$ | 3.30 | 85.43 | 13.7 | 4.61 | 1.63 | 6.28 |
| $T_6$ | 3.45 | 87.78 | 14.21 | 5.18 | 1.67 | 6.36 |
| $T_7$ | 3.21 | 80.96 | 12.18 | 3.53 | 1.51 | 5.12 |
| CD at 5% | 0.31 | 8.87 | 2.75 | 1.51 | NS | 1.05 |

$cm^2$), secondary (6.66 $cm^2$), tertiary branches (1.97 $cm^2$) and canopy volume (8.21 $m^3$) were recorded in 100 % recommended dose of fertilizer (RDF) through fertigation and at par with $T_4$ treatment. It is 12.53 % plant height, 20.02% cross sectional area of main trunk, 40.61% primary, 46.99% secondary and 23.35% tertiary branches and 37.64% canopy volume higher over control treatment. The higher vegetative growth was recorded in $T_2$ treatment might be due to optimum availability of applied nutrients as well as their effective utilization by the plants. Results are inconformity with the findings of Rao and Subramanyam (14) while working on pomegranate, the vegetative growth was positively related to the amount of nitrogen applied through drip/fertigation. Similar results obtained by Ahmad *et al.* (1) while working in sweet cherry.

A perusal of data presented in Table 2 clearly indicated that nut number, weight and yield as influenced by fertigation techniques in almond. The pooled data of three years showed maximum nut number (2208 /tree) was recorded in 100% RDF through fertigation closely followed by $T_4$ (2180 /tree) and minimum (904/tree) was in control treatment. The higher nut number with $T_2$ treatment might be due to the fact that the application RDF through fertigation improve the nut retention in almond. Whereas, highest nut weight (2.29 g) was recorded in $T_5$ treatment (50% RDF through fertigation) which is at par with $T_4$ and $T_6$ treatment. The nut number is negatively correlated with nut weight. The improvement in nut weight in $T_5$ treatment might be due to more nutrient diverted for development of limited number of fruit available on the tree. The highest nut yield (4.94 kg/tree and 5.48 t/ha) was recorded in $T_4$ treatment closely followed by $T_2$ treatment (4.57 kg/tree and 5.07 t/ha) and significantly superior over other treatments. The higher fruit yield obtained in T4 treatment might be due to efficient utilization of nutrients as per the growth stages and reduction in nutrient leaching that resulted in better yield. Similar results were reported by Ahmad *et al*. (1) and Kumar and Ahmed, (8) while working on cherry and almond crop.

**Table 2.** Nut number, weight and yield as influenced by fertigation in almond.

| Treatment | Nut number | Nut wt (g) | Nut yield (kg/tree) | Yield (t/ha) |
|---|---|---|---|---|
| $T_1$ | 1491 | 2.11 | 3.15 | 3.50 |
| $T_2$ | 2208 | 2.07 | 4.57 | 5.07 |
| $T_3$ | 1787 | 2.09 | 3.73 | 4.14 |
| $T_4$ | 2180 | 2.27 | 4.94 | 5.48 |
| $T_5$ | 1219 | 2.29 | 2.79 | 3.09 |
| $T_6$ | 1424 | 2.22 | 3.16 | 3.51 |
| $T_7$ | 904 | 2.03 | 1.84 | 2.04 |
| CD at 5% | 297 | 0.22 | 0.82 | 0.73 |

Data presented in Table 3 indicated that nut size, kernel weight and size and shell weight as influenced by fertigation techniques in almond (Table 3). Maximum nut dimension (36.25 × 21.33 mm), and kernel weight and dimension (1.45 g and 24.62 × 14.54 mm) were recorded with $T_5$ treatment followed by $T_4$ treatment (36.25 × 21.33 mm nut dimension; 1.45 g kernel weight and 24.62 × 14.54 mm kernel dimension) and minimum was in control (25.45 × 16.23 mm nut dimension; 1.05 g kernel weight and 18.56 × 11.23 mm kernel dimension), respectively. As per the nut quality, lighter the shell weight better the quality. Non significant variations were obtained in respect to shell weight among the fertigation treatment. The maximum nut size and kernel weight and size were recorded in $T_5$ treatment might be due to more nutrient diverted for the development of limited fruits on the tree. Similar findings reported by Kumar and Ahmed, (8).

**Table 3.** Nut characters as influenced by fertigation in almond cv. Waris.

| Treatment | Kernel wt (g) | Nut size (mm) | Kernel wt (g) | Kernel size (mm) | Shell wt (g) |
|---|---|---|---|---|---|
| $T_1$ | 1.35 | 35.21 x 21.25 | 1.35 | 24.17 x 14.15 | 0.76 |
| $T_2$ | 1.30 | 33.15 x 20.12 | 1.30 | 23.21 x 13.22 | 0.77 |
| $T_3$ | 1.32 | 33.50 x 20.31 | 1.32 | 23.45 x 13.35 | 0.77 |
| $T_4$ | 1.45 | 36.25 x 21.33 | 1.45 | 24.62 x 14.54 | 0.82 |
| $T_5$ | 1.48 | 36.51 x 21.56 | 1.48 | 24.71 x 14.59 | 0.81 |
| $T_6$ | 1.35 | 34.25 x 20.45 | 1.35 | 23.89 x 13.56 | 0.87 |
| $T_7$ | 1.05 | 25.45 x 16.23 | 1.05 | 18.56 x 11.23 | 0.98 |
| CD at 5% | 0.12 | NS | 0.12 | NS | NS |

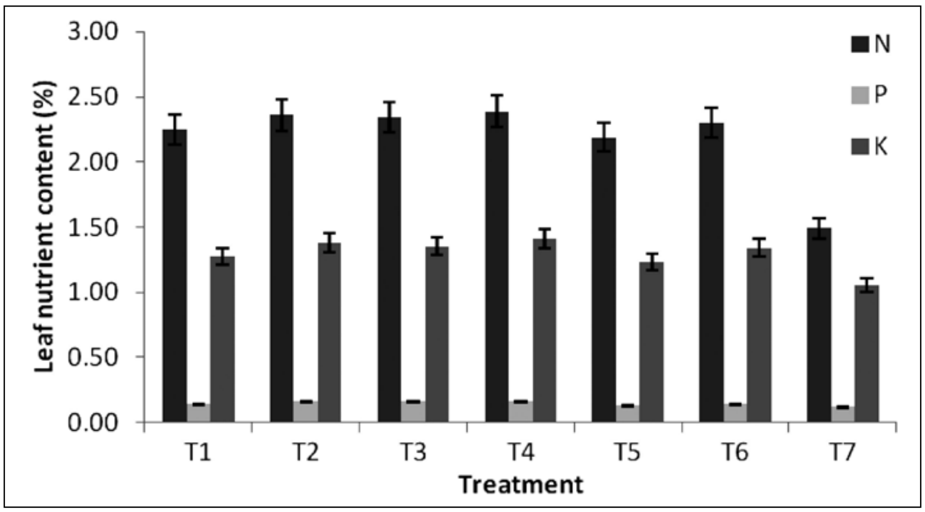


**Fig. 1.** Leaf NPK as influenced by fertigation in almond.

Leaf nitrogen, phosphorus and potassium content as influenced by fertigation techniques in almond (Fig. 1). Maximum leaf nitrogen (2.39 %) and potassium (1.41%) were recorded with $T_4$ treatment closely followed by $T_2$ treatment (2.36 % N and 1.38%K) and $T_3$ (2.34%N and 1.35%K) treatment, respectively. It is 37.65% N and 25.53%K ; 36.86%N and 23.91%K; 36.33%N and 22.22%K higher and significantly superior over control treatment. The leaf phosphorus content were non significant among the fertigation treatments. The higher nitrogen and potassium content in leaf in $T_4$ might have accounted for higher uptake of these nutrients. Similar increase in leaf nutrient content has been reported by Murthy *et al.*(10) and Neilsen *et al*. (11).

The present study could be concluded that the application of 75% RDF through fertigation (applied N:K in the ratio of 2/3N:1/3K at nut set to nut development and 1/3N:2/3K at kernel filling to maturation stage) increases nut yield in almond by enhancing fertilizer use efficiency besides saving of input cost under Kashmir valley conditions.

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