



## Impact of integrated nitrogen management on nut yield and soil fertility in almond (*Prunus dulcis*) under north western Himalayan region of India

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### ABSTRACT

To improve nut yield and soil fertility, a study on nitrogen management was taken up on eight year old almond (*Prunus dulcis* L.) grafted plants of commercial variety Waris spaced at 3.5 × 3.5m and treatments were imposed in 2009. The results of long term experimentation clearly indicated that maximum mean nut yield (3.16 kg/tree and 2.71 tonnes/ha) was recorded with the application of 40 tonnes/ha FYM followed by 100% RDF + 10 tonnes/ha FYM (2.83 kg/tree and 2.41 tonnes/ha) and minimum (1.61 kg/tree and 1.73 tonnes/ha) was recorded in control plots (No fertilizer). The fertility status of soil also improved by application of organic and inorganic fertilizers, the available nitrogen, phosphorus and potassium content (46.13, 26.8, 38.67%) were estimated with the application of 40 tonnes FYM/ha in almond variety Waris under north western Himalayan region of India.

**Key words:** Almond, Integrated Nitrogen Management, Nut yield, Soil fertility

Almond (*Prunus dulcis* L.) is one of the important nut crops of temperate region of the country, mainly grown in Jammu and Kashmir. In India, it is grown over an area of 23.2 thousand ha with an annual production of 16.3 thousand tonnes with an average productivity of 0.7 tonne/ha which is very less as compared to other almond producing countries of the world. The almond kernels are concentrated source of energy with a significant share of fat, protein and fibre. Fats are primarily non saturated fatty acid which is important in maintaining low cholesterol level in the blood and significant amount of micro-nutrients (Aslanta 2001). Commercial almond production in India is low considering the demand and economical potential. The almond demand is increasing day by day and it is being imported for worth ₹ 1061 crores annually (Anonymous 2014).

Almond is a heavy feeder and it requires substantial amount of manure and fertilizers (Ahmed and Verma 2009). Integrated nitrogen management play an important role in increasing the production and potential of almond in the region. Application of integrated manure and fertilizers may be better option for enhancing yield and quality of apple (Verma and Chauhan 2013). In general most of the farmers apply fertilizers in single soil application during dormant season and no fertilizers are applied during vegetative, flowering and fruit growth stages in almond (Kumar and Ahmed 2014). Application of different nutrients through

inorganic fertilizers, manure and biofertilizers increased the nitrogen, phosphorus and potassium contents in soil (Dutta *et al.* 2010). Manipulation of vegetative and reproductive balance in horticultural crops through nitrogen nutrition is reported (Huett 1996).

An increasing use of chemical fertilizers to increase production of crops has been widely recognized but its long term impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil micro-flora and human being. The cost of chemical fertilizer is also increasing day by day hence, adoption of integrated plant nutrient offers scope for sustainable crop production and improve soil fertility (Lal and Kanaujia 2013). The integration of manure and fertilizers would not only pave way for overcoming the deficiencies of these vital nutrients in plants but also strengthen the integrated plant nutrient management programme. The systematic information is not available in almond especially integrated nitrogen management under Kashmir valley condition. Therefore, the present investigation was aimed to increase production and potential of almond by INM under north western Himalayan region of India.

### MATERIALS AND METHODS

The present study was conducted at Research Farm of ICAR-Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir, India during 2009 to 2013. The research farm at Srinagar is situated at latitude of 34°05'N and longitude of 74°50'E and at an altitude of 1640 m above MSL. The soil of this experimental field is sandy clay loam (39.60% sand, 24.0% silt and 36.40% clay) with medium to

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low soil fertility. The experimental farm falls under temperate region having cold conditions from November to February and five year mean maximum and minimum temperature of Srinagar climate indicated maximum (30°C) in August and minimum (-2.1°C) in December. The average annual precipitation was 650 mm distributed erratically throughout the year during the course of investigation.

The grafted almond plants were planted in pre-filled pits dimension of 90 × 90 × 90 cm during November, 2002 at a spacing of 3.5 × 3.5 m in an experimental field. Treatment applied on eight year old uniform plantations of almond variety Waris during 2009. The treatment comprised of T<sub>1</sub>-Control, T<sub>2</sub>- 50% RDF of nitrogen, T<sub>3</sub>- 75% RDF of nitrogen, T<sub>4</sub>- 100% RDF, T<sub>5</sub>- 125% of RDF, T<sub>6</sub>-50% RDF + 20 t FYM/ha, T<sub>7</sub>-75% RDF + 15 t FYM/ha, T<sub>8</sub>- 100% RDF + 10 t FYM/ha and T<sub>9</sub>- 40 t FYM/ha, replicated thrice under Randomised Block Design. The recommended dose of fertilizer was applied as per the package of practices developed by SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir. The organic and inorganic fertilizers were applied as per the treatment in experimental field. The chemical fertilizers were applied before bloom and after fruit set. Nitrogen was applied in 3 split doses, first dose (half the quantity) applied along with full dose of phosphorus and potassium a fortnight before the bloom, second dose of nitrogen (1/4 of the total quantity) applied three week after fruit set and third dose (1/4 of total quantity) applied in June. The full quantity of farmyard manure applied in December on fresh weight basis. The experimental field was irrigated by drip irrigation and other cultural practices followed on uniform basis.

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 of the width as the 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.* 2006).

CV measurements were made after harvest in October 2009, 2010, 2011, 2012 and 2013. Tree trunk girth was recorded before the execution and at the end of experiment during study period. A ring was made with red paint at a height of 15 cm 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, dried and yield/tree and per hectare was recorded in kilogram and tonnes. The productivity efficiency was calculated by the formula:

$$\text{Productivity efficiency} = \frac{\text{Nut yield (g/tree)}}{\text{TCSA (cm}^2\text{)}} \text{ (g/cm}^2\text{ TCSA)}$$

Soil samples from various treatments were collected from 0-30 cm depth in November each year, shade dried, ground sieved through a 2 mm sieve and processed for subsequent analyses of available nitrogen, phosphorus and potassium following standard procedure (Page *et al.* 1982). The data were analysed statistically as per the Steel and Torrie (1986) for interpretation of results and drawing conclusion.

## RESULTS AND DISCUSSION

### Trunk cross sectional area (TCSA)

The trunk cross sectional area (TCSA) of tree was influenced by integrated nitrogen management in almond which increases over the year in all the treatments. In 2009 and 2010, maximum TCSA (55.15 cm<sup>2</sup> and 77.75 cm<sup>2</sup>) was recorded in the treatment of 75% recommended dose of fertilizer which is superior over the T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> treatment and at par with rest of the treatments. In 2011, the maximum TCSA (122.99 cm<sup>2</sup>) was recorded in T<sub>5</sub> treatment. However, in 2012 and 2013, it was highest (128.18 and 135.45 cm<sup>2</sup>) in T<sub>9</sub> treatment (40 t FYM/ha). Overall mean data of consecutive five years indicated that maximum TCSA (100.94 cm<sup>2</sup>) was recorded in T<sub>9</sub> treatment and at par with T<sub>6</sub>, T<sub>5</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>8</sub> and T<sub>7</sub> treatment and significantly superior over T<sub>1</sub> and T<sub>2</sub> treatment in almond (Table 1). The maximum

Table 1 Effect of integrated nitrogen management on vegetative growth of almond var. Waris

Treatment	TCSA (cm <sup>2</sup> )						Canopy volume (m <sup>3</sup> )					
	2009	2010	2011	2012	2013	Mean	2009	2010	2011	2012	2013	Mean
T1	42.55	72.75	96.86	98.08	106.60	84.37	6.81	7.25	9.27	12.11	13.45	9.78
T2	46.15	64.44	106.01	108.25	111.42	87.25	7.78	8.12	10.24	13.21	14.37	10.74
T3	55.15	77.75	118.25	122.53	126.45	99.03	8.47	9.94	11.51	13.45	14.84	11.64
T4	43.78	61.66	120.23	123.99	128.12	95.55	8.84	9.98	11.83	13.65	14.98	11.85
T5	51.64	70.56	122.99	125.24	130.14	100.11	9.31	10.56	12.15	13.85	15.12	12.19
T6	54.86	72.56	120.35	124.13	129.69	100.32	9.42	10.72	12.25	14.42	15.64	12.49
T7	47.75	66.91	113.16	118.62	124.24	94.14	9.67	11.25	12.41	14.65	15.86	12.77
T8	51.40	68.44	111.18	119.24	125.84	95.22	9.98	11.31	12.65	15.15	16.28	13.07
T9	50.68	67.97	122.46	128.18	135.45	100.94	9.57	11.25	12.56	15.43	16.75	13.11
SEm±	3.15	3.05	4.53	4.17	5.28	3.04	0.42	0.58	0.66	0.54	0.53	0.53
CD (P=0.05)	8.69	8.15	12.11	11.15	14.12	8.11	1.13	1.55	1.76	1.45	1.42	1.44

TCSA under T<sub>9</sub> treatment might be due to regular addition of farmyard manure having a positive impact on the buildup of soil fertility. Saha *et al* (2010) reported that farm yard manure significantly influenced the growth parameters of mango tree over the seasons. There was a positive and linear relationship between increasing rates of FYM application and TCSA.

#### Canopy volume

Canopy volume was influenced by different INM treatments in almond (Table 1). It increased with increasing the age of tree over the years in all the treatments. Maximum canopy volume (9.98 m<sup>3</sup>, 11.31 m<sup>3</sup> and 12.65 m<sup>3</sup>) was recorded in T<sub>8</sub> treatment during 2009, 2010, 2011 which is superior over other treatments. In 2012 and 2013, maximum canopy volume (15.43 m<sup>3</sup> and 16.75 m<sup>3</sup>) were recorded in T<sub>9</sub> which is superior over other treatments. The overall mean of five years data indicated that maximum canopy volume (13.11 m<sup>3</sup>) was recorded in T<sub>9</sub> closely followed with T<sub>8</sub>, T<sub>7</sub>, T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub> which was significantly superior over T<sub>3</sub>, T<sub>2</sub> and T<sub>1</sub> in almond. The highest canopy volume of almond tree recorded in might be due to continuous addition of farmyard manure and uptake by plants leading to increase in canopy volume. Organic manure and RDF increased the concentration of nutrients in the root zone, which maintained active translocation of nutrients and increased plant growth. Similar improvements in plant growth in mango trees have also been reported by Dixit *et al.* (2003). Low plant growth in control plots was probably due to the low availability of nutrients.

#### Nut yield

Nut yield influenced by different in almond (Table 2). Maximum nut yield (1.45 kg/tree and 1.18 tonnes/ha) was recorded in T<sub>8</sub> which was superior to other treatments in 2009. During 2010, maximum nut yield (3.49 kg/tree and 2.85 tonnes/ha) was recorded in T<sub>9</sub>. The nut yield again reduced during 2011 in all the treatments and maximum yield (2.24 kg/tree and 1.82 tonnes/ha) was recorded in T<sub>9</sub>. In 2012 and 2013 nut yield increased and decreased due to

a tendency of on/off year in almond. The mean maximum yield (3.16 kg/tree and 2.71 t/ha) was recorded in T<sub>9</sub> which was superior over other treatments. The maximum nut yield in T<sub>9</sub> might be due to continuous supply of optimum nutrient as per the phenological stages of nut growth and kernel filling in almond. Similar findings were also reported by Kumar and Ahmed (2014).

#### Productivity efficiency

Productivity efficiency as influenced by different treatment of INM in almond has been shown in Table 3. Maximum productivity efficiency (28.21 g/cm<sup>2</sup> TCSA) was recorded in T<sub>8</sub> which was significantly superior over control in 2009. In 2010, maximum productivity efficiency (51.34 g/cm<sup>2</sup> TCSA) was recorded in T<sub>9</sub> which is at par with T<sub>4</sub>, T<sub>2</sub> and T<sub>6</sub> and superior to T<sub>8</sub>, T<sub>7</sub>, T<sub>5</sub>, T<sub>3</sub> and T<sub>1</sub>. The productivity efficiency reduced in 2011 in all the treatments. But maximum productivity efficiency (18.29 g/cm<sup>2</sup> TCSA) was with T<sub>9</sub> treatment. During 2012, maximum productivity efficiency (38.74 g/cm<sup>2</sup> TCSA) was recorded in T<sub>8</sub> which was significantly superior over T<sub>6</sub>, T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub>, T<sub>2</sub> and T<sub>1</sub> and

Table 3 Effect of INM on productivity efficiency of almond cv. Waris

Treatment	Productivity Efficiency (g/cm <sup>2</sup> TCSA)					
	2009	2010	2011	2012	2013	Mean
T1	20.91	20.06	8.56	27.32	19.79	19.33
T2	22.10	45.62	10.94	24.94	23.51	25.42
T3	20.85	40.27	9.97	26.27	24.19	24.31
T4	27.41	46.70	10.24	29.43	25.52	27.86
T5	23.82	35.99	13.46	30.34	24.28	25.58
T6	23.33	45.34	14.75	30.85	27.37	28.33
T7	27.64	43.37	15.11	34.56	28.33	29.80
T8	28.21	39.59	13.88	38.74	29.08	29.90
T9	24.86	51.34	18.29	36.90	30.19	32.32
SEm±	2.54	5.21	2.23	3.15	2.79	3.04
CD	6.85	14.07	6.02	8.51	7.53	8.21

(P=0.05)

Table 2 Effect of integrated nitrogen management on nut yield in almond var. Waris

Treatment	Nut yield (kg/tree)						Nut yield (t/ha)					
	2009	2010	2011	2012	2013	Mean	2009	2010	2011	2012	2013	Mean
T1	0.89	1.56	0.83	2.68	2.11	1.61	0.72	1.27	0.68	2.18	1.72	1.73
T2	1.02	2.94	1.16	2.70	2.62	2.09	0.83	2.40	0.95	2.20	2.14	1.81
T3	1.15	2.93	1.18	3.22	3.06	2.31	0.94	2.39	0.96	2.62	2.50	1.99
T4	1.20	2.88	1.26	3.65	3.27	2.45	0.98	2.35	1.03	2.97	2.67	2.10
T5	1.23	2.54	1.62	3.80	3.16	2.47	1.01	2.07	1.32	3.10	2.58	2.11
T6	1.28	3.29	1.67	3.83	3.55	2.72	1.04	2.68	1.36	3.13	2.90	2.34
T7	1.32	2.93	1.68	4.10	3.52	2.71	1.08	2.39	1.37	3.35	2.87	2.32
T8	1.45	2.71	1.70	4.62	3.66	2.83	1.18	2.21	1.38	3.77	2.99	2.41
T9	1.26	3.49	2.24	4.73	4.09	3.16	1.03	2.85	1.82	3.85	3.34	2.71
SEm±	0.10	0.17	0.25	0.24	0.29	0.29	0.08	0.17	0.20	0.20	0.21	0.18
CD (P=0.05)	0.27	0.45	0.65	0.62	0.76	0.75	0.22	0.45	0.51	0.53	0.55	0.48

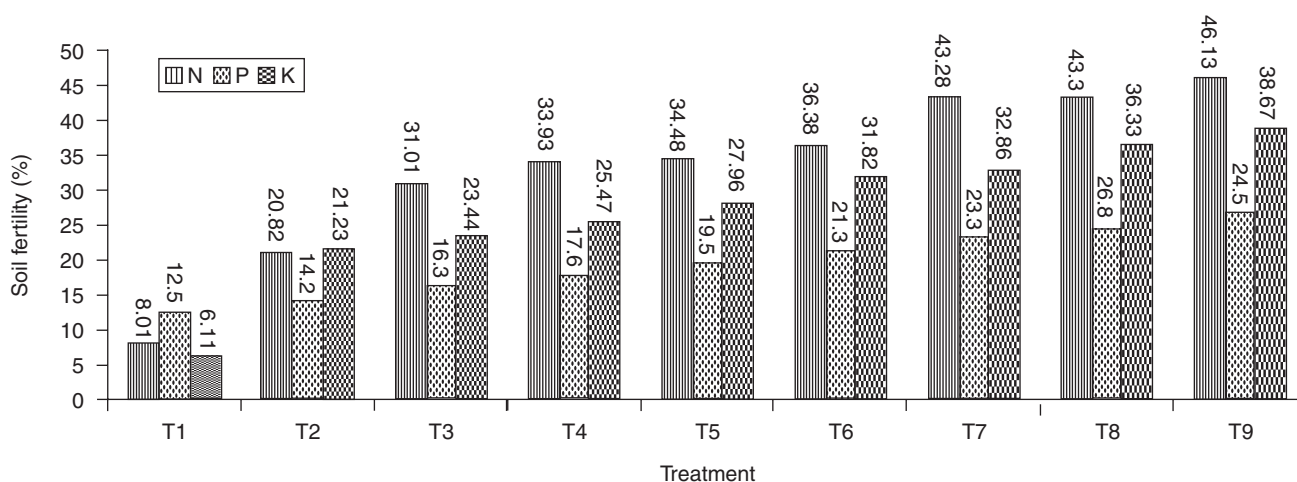


Fig 1 Soil fertility improvement over the year under different treatment in almond

at par with T<sub>7</sub> and T<sub>9</sub>. During 2013, maximum productivity efficiency (30.19 g/cm<sup>2</sup> TCSA) was recorded in T<sub>9</sub> which is at par with T<sub>2</sub> and T<sub>1</sub>. The pooled data of five years indicated that significantly maximum productivity efficiency (32.32 g/cm<sup>2</sup> TCSA) was recorded in T<sub>9</sub> which is superior over T<sub>5</sub>, T<sub>3</sub>, T<sub>2</sub> and T<sub>1</sub> and at par with T<sub>8</sub>, T<sub>7</sub>, T<sub>6</sub> and T<sub>4</sub> treatment. The higher productivity efficiency in T<sub>9</sub> treatment might be due to more nut yield in the same treatment there by improved the productivity efficiency. Similar findings were also reported by Kumar and Ahmed (2014) in almond.

#### Soil nutrient status

Soil samples were collected under different treatments for available nutrient analysis in almond (Fig 1). The collected soil samples (before initiation and after completion of experiment) were analysed for available N, P and K. The percent improvement over the year in soil available N, P and K content indicated that maximum soil available nitrogen, phosphorus and potassium (46.13, 26.8, 38.67%) were estimated in T<sub>9</sub> (40 tonnes FYM/ha) followed by T<sub>8</sub>, T<sub>7</sub> and T<sub>6</sub>. Regular addition of farmyard manure had a positive impact on the build up of available N, P and K from organic sources (Verma and Sharma 2000).

From the long term experimentation, it could be concluded that integration of organic and inorganic fertilizers or organic manure alone improve the nut yield as well as soil fertility and also conserve of natural resources under north western Himalayan region of India.

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