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Yield, fruit quality and leaf nutrient status of aonla as influenced by intercropping under integrated nutrient management

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ABSTRACT

Aonla or Indian gooseberry responds well to intercropping of tuber crops, provided that management practices is followed as per requirement of fruit trees. The experiment was conducted to evaluate the impact of intercropping suran (Amorphophallus) under integrated nutrient management on yield, fruit quality and leaf nutrient status of aonla trees. The highest dry matter, nitrogen, phosphorus and potassium content of leaves in aonla + suran based intercropping system was reported with the treatment containing urea, vermicompost and mustard cake @ (2:1:1) as source of nitrogen. This treatment also resulted in highest fruit yield (36.95 kg/tree in first year and 38.40 kg/tree in second year) and improved fruit quality parameters like total soluble solids (TSS), acidity, Vitamin-C and total sugar.

Keywords: Fruit weight, mustard cake, urea, vitamin c and vermicompost

Aonla (*Emblica officinalis* Geartn.), also known as the Indian Gooseberry, is an ancient fruit of Indian origin. It is associated with Indian tradition, culture, heritage and Ayurveda which is backbone of Indian medicine. It is an important ingredient of Triphala and Chayavanprash. Aonla is one of the richest source of vitamin–C (500–700mg / 100g of pulp) and is useful in haemorrhages, diarrhoea, dysentery, anaemia, jaundice, dyspepsia and has good tolerance to salinity, alkalinity and has ability to withstand drought condition. Aonla is a deciduous fruit tree in which flowering and fruit set occurs in spring, following this, fruit enter to dormancy till monsoon. The ignorance during summer can be detrimental for aonla production so this phase can be effectively utilized for cultivation intercrops under plantation of aonla. Integrated nutrient management (INM) of intercrop is beneficial for improving nutrient level of aonla trees so improves the fruit yield and quality of aonla. Proper orchard floor management through intercropping and INM after fruit set results in better fruit growth, yield and fruit quality.

The INM is economically cheap, technically sound, practically feasible and capable of maintaining the sustainability in the production. Mustard cake and vermi-compost bear capacity of slow nutrients release so have long term impact on soil and plants preferably fruit trees thus have great scope for application in INM of orchard. The INM approach includes improvement of soil fertility through combined application of organic and inorganic sources of nutrients in appropriate dose and at right time (Woomer and Swift, 1994; Palm *et al*., 2001; Vanlauwe and Giller, 2006; Tittonell *et al*., 2008; Chivenge *et al*., 2011) or through growing leguminous crops as intercrops (Kimaro *et al*., 2009 and Chamshama *et al*., 2006) in combination with growing improved germplasms (Vanlauwe *et al.*, 2010). The positive interaction between both inputs of nutrients, organic and inorganic, is essential to ensure better soil health and crop productivity (Vanlauwe *et al*., 2002). The vegetable crops like elephant foot yam, colocassia, turmeric, cassava, turmeric and ginger have greater potential to grow and perform well under shade of fruit trees. This might be due to their greater biological efficiency to perform photosynthesis through efficient solar energy transfer and the highest rate of dry matter production per unit area per day among all crops. Thus, present research paper put emphasis on significance of intercropping suran (*Amorphophallus*) under integrated nutrient management on yield, fruit quality and leaf nutrient of aonla.

MATERIALS AND METHODS

The investigation has been undertaken at farmer's field of Faizabad (U.P.) region for two consecutive years to evaluate the effect of intercropping of suran (*Amorphophallus*) under INM on leaf nutrient status, fruit yield and quality of aonla. Geographically, Faizabad district falls in subtropical climate which is situated at 24.47^0N latitude and 82.12^0E longitude at an altitude of 113 metres from sea level. The soil of aonla orchard contains sand, silt and clay in proportion of 3:2:5 with saline soil pH (8), available nitrogen (N) 175 kg ha^{-1} hectare, available phosphorus (P) 22.5 kg ha^{-1} and available potassium (K) 270 kg ha^{-1}.

A basal dose (800 : 400 : 800 g NPK plant^{-1}) of fertilizers and rotten farm yard manure (10 tonnes ha^{-1}) was applied after harvesting of aonla crops in January.

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Suran was planted during last week of February, 2007 by using corms of 200g weight and plant spacing was kept at 50 cm apart (Row x Plant) in the pits of size 45 x 45 x 45 cm. N: P: K @ 40:30:50 (in kg ha^{-1}) was applied by different sources *viz*. urea, mustard cake vermicompost, SSP (single super phosphate) and MOP (muriate of potash) as per different treatments. The treatment applied were: T_1-100% N from urea, T_2-25% N from vermicompost + 75% N from urea, T_3-50% N from vermicompost + 50% N from urea, T_4-75% N from vermicompost + 25% N from urea, T_5-25% N from mustard cake + 75% N from urea, T_6-50% N from mustard cake + 50% N from urea, T_7-75% N from mustard cake +25% N from urea, T_8-25% N from mustard cake + 25% N from vermicompost + 50% N from urea, T_9-100% N from vermicompost, T_{10}-100% N from mustard cake, and T_{11}-aonla as sole crop. First irrigation was given after 25 days of planting. Second manuring was provided in aonla in last week of August for better fruit growth from mid-August to November and to reduce the fruit drop.

The nutrients content of aonla leaves was estimated by sampling three months old shoots taken from the middle portion of the indeterminate shoots during December as suggested by Awasthi *et al.* (1993). The sampled leaves were estimated for dry matter, N, P and K content as proposed by Baruah and Banthakur (1998). The average fruit volume and fruit weight were recorded on twenty randomly selected matured fruits from each tree. The fruit yield of aonla was estimated on the basis of the total number of fruits per tree and the average fresh weight of fruits harvested at full maturity. The fruit quality of aonla was analysed by determining TSS, titratable acidity, ascorbic acid, reducing and total sugar (Horwitz and Latimer, 2005). The experimental design used for analysis was RBD (randomized block design). The observations recorded on different aspects were statistically analysed. The analysis of variances, standard error and critical difference were computed using the statistical methods as described by Cocharan and Cox (1965).

RESULTS AND DISCUSSION

Leaf nutrient status of aonla

The data recorded on leaf analysis for dry matter, N, P, and K (Table 1) exhibited that there was no significant difference in nutrient levels of aonla leaves, due to intercropping of suran with different sources of nitrogen. The dry matter content in aonla leaves ranged from 73.92 to 79.31%, nitrogen from 1.96 to 2.10%, phosphorous from 0.192 to 0.210% and potassium from 1.382 to 1.480%. The higher concentration (79.31% dry matter, 2.10% nitrogen, 0.210% phosphorus and 1.480% potassium) of leaf nutrients were recorded in T_8 (Aonla + Suran + 25% N from Mustard cake + 25% N from Vermicompost + 50% N from Urea), followed by T_3 (Aonla + Suran + 50% N from Vermicompost +50% N from Urea) and T_2 (Aonla + Suran +25% N from Vermicompost + 75% N from Urea), whereas, the nutrients content was least in mono-cropped aonla trees. Organic sources of nitrogen for intercrop might have provided additional doses of nutrients in a sustainable way throughout the growing phase. This finding is supported by earlier findings of integrated nutrient management (NPK + FYM + Biofertilizers) on leaf nitrogen, phosphorus and potassium level of aonla (Bala *et al.,* 2012).

Yield and yield attributing characters of aonla

Intercropping with suran did not show significant variation in fruit yield (Table 2) of aonla during first year (2007-08) while in second year (2008-09) both fruit weight and volume increased significantly to give significant result in yield. In year 2007-08, the average weight of fruits varied from 39.36 to 42.23 g, while the fruit volume varied from 38.59 to 41.00 ml. The maximum fruit yield (36.95 kg/tree) was recorded in T_8 (Aonla + Suran + 25% N from Mustard cake + 25% N from Vermicompost + 50% N from Urea), followed by 35.78 kg/tree in T_3 (Aonla + Suran + 50% N from Vermicompost +50% N from Urea) and 35.72 kg/tree in T_2 and T_9. In subsequent year (2008-09), the highest fruit volume (42.32 ml) was reported in T_3 followed by T_9 (42.15 ml). Fruit volume of treatments T_3, T_9, T_{10}, T_7, T_4 and T_8 were significantly greater than T_1 (where 100 percent RDF was applied) and T_{11} (sole crop) while other treatments were at par. The average fruit weight of aonla was significantly better in T_9 (43.30g), T_{10} (43.25g), T_7 (43.20g) and T_8 (43.00g) in comparison to T_{11} (39.25g) while other treatments were at par. The fruit yield was also reported to be significantly high in treatments where RDF has been replaced with vermicompost or mustard cake alone or in combination. Fruit yield per tree was higher in T_8 (38.40 Kg), T_4 (38.15 Kg), T_3 (38.00 Kg), T_7(38.00 Kg), T_9 (38.00 Kg) and T_{10} (37.60 Kg) in comparison to T_1 (35.50 Kg) and T_{11} (34.00 Kg) while other treatments were at par. Thus, it is apparent form the result that the fruit yield of aonla was not adversely affected by intercropping. Similar observations had also been reported earlier for intercropping seasonal crops in perennial trees plantation (Sharma, 1999 and Das, *et al*., 2011). It might be due to restricted growth behaviour and shallow root system of intercrops grown for short gestation period underneath the tall growing perennial trees of aonla or increased fertilizer availability and fertilizer use efficiency (FUE) under integrated nutrient

Table 1: Leaf nutrient content of aonla as influenced by intercropping under INM

Treatments	Dry matter (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	74.69	1.98	0.194	1.397
T_2	78.54	2.08	0.204	1.469
T_3	78.93	2.09	0.205	1.476
T_4	78.16	2.07	0.203	1.462
T_5	77.77	2.06	0.202	1.454
T_6	77.00	2.04	0.200	1.440
T_7	76.85	2.04	0.200	1.440
T_8	79.31	2.10	0.210	1.480
T_9	76.38	2.02	0.198	1.428
T_{10}	75.46	2.00	0.196	1.411
T_{11}	73.92	1.96	0.192	1.382
Mean	77.00	2.04	0.200	1.440
SEm(±)	**2.481**	**0.066**	**0.007**	**0.047**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**

**NS: The effect of treatments is non-significant*

Table 2: Yield and yield attributing characters of aonla as influenced by inter cropping under INM

Treatments	Fruit weight (g)		Fruit volume (ml)		Fruit yield (kg. tree^{-1})	
	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2
T_1	39.77	40.12^{ab}	38.95	39.05^{b}	33.95	35.50^{b}
T_2	41.82	41.85^{ab}	40.68	40.70^{ab}	35.72	37.20^{ab}
T_3	42.03	42.50^{ab}	41.00	42.32^{a}	35.78	38.00^{a}
T_4	41.62	42.80^{ab}	40.64	41.95^{a}	35.50	38.15^{a}
T_5	41.41	41.80^{ab}	40.48	40.50^{ab}	35.40	36.80^{ab}
T_6	41.00	42.82^{ab}	40.16	41.64^{ab}	35.60	37.05^{ab}
T_7	40.92	43.20^{a}	40.00	42.00^{a}	35.40	38.00^{a}
T_8	42.23	43.00^{a}	41.00	41.90^{a}	36.95	38.40^{a}
T_9	40.67	43.30^{a}	39.80	42.15^{a}	35.72	38.00^{a}
T_{10}	40.18	43.25^{a}	39.32	42.10^{a}	34.80	37.60^{a}
T_{11}	39.36	39.25^{b}	38.59	38.80^{b}	33.80	34.00^{b}
Mean	41.001	42.172	40.056	41.193	35.329	37.218
SEm(±)	**1.321**	**1.125**	**1.295**	**0.868**	**1.154**	**1.062**
LSD(0.05)	**NS**	**3.6**	**NS**	**2.62**	**NS**	**1.8**

NS: non-significant

management system. The increased production of aonla due to intercropping of *Amorphophallus* is in conformity with the findings of Kumar *et al.* (2002) through aonla based horti-pastoral system. Laishram and Ghosh (2017) had also reported increased yield in Jackfruit due to intercropping of cowpea followed by chick pea.

Quality attributes of aonla fruits

The fruits contained (Table 3) 8.160 to 8.755% TSS, 624.00 to 669.50 mg ascorbic acid/100g of edible part, 1.800 to 1.840% acidity, 2.400% to 2.575% reducing sugar, 2.112% to 2.266% non reducing sugar and 4.512% to 4.841% total sugar in various treatments. Data recorded on all chemical attributes of aonla fruits revealed that there was a non-significant variation in quality of aonla fruits due to intercropping and INM practices. However, growing of suran with application of nitrogen from all possible sources *viz*. vermicompost, mustard cake and urea had shown relatively better quality of fruits as compared to aonla grown as sole crop. This might be due to additional nutrient application and less uptake of nutrients by the intercrop, and better fertilizer use efficiency (FUE). The growing of suran did not adversely affect fruit quality because of their restricted

Table 3: Quality of aonla fruits as influenced by intercropping under INM

Treatments	TSS (%)	Acidity (%)	Vitamin –C (mg $100g^{-1}$)	Reducing sugar (%)	Total sugar (%)
T_1	8.245	1.81	630.5	2.425	4.559
T_2	8.67	1.83	663	2.55	4.794
T_3	8.713	1.833	666.25	2.563	4.818
T_4	8.628	1.825	659.75	2.538	4.771
T_5	8.585	1.823	656.5	2.52	4.742
T_6	8.5	1.822	650	2.505	4.705
T_7	8.48	1.82	648.7	2.495	4.691
T_8	8.755	1.84	669.5	2.575	4.841
T_9	8.432	1.814	644.8	2.48	4.662
T_{10}	8.33	1.81	637	2.45	4.606
T_{11}	8.16	1.8	624	2.4	4.512
Mean	8.5	1.821	668.18	2.5	4.701
SEm(±)	**0.275**	**0.059**	**20.95**	**0.081**	**0.153**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**

NS: non-significant

growth and less requirement of nutrients. The non-significant effect of intercropping of tuber crops like ginger, turmeric and arvi on chemical attributes of aonla was reported earlier by Das, *et al.* (2011). However, highest fruit number and vitamin-C in aonla had been reported by Korwar, *et al.* (2006) through combined application of vermicompost and FYM.

It was concluded that intercropping suran with various integrated source of nutrients did not affect the aonla crop significantly. The combination of 25% N from mustard cake + 25% N from vermicompost + 50% N from urea in suran is most effective for enhancing leaf nutrient, fruit weight and yield of aonla.

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