Growth, yield and economics of amla (*Emblica officinalis* L.) based agri-horticultural system in Alfisols of semi-arid tropic

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**ABSTRACT**

An intercropping trial conducted during 2011 to 2017 using five year old amla (*Emblica officinalis* L.) orchard planted at 4 X 4 m spacing and grown under rainfed condition to identify the suitable and profitable intercrops. The intercrops viz, finger millet, fodder maize, field bean, grain amaranth, cowpea, horsegram were considered in the study besides their pure stand. Growth parameter of amla such as plant height (369 cm), number of branches/tree (2.73), stem diameter (35.31 cm), canopy spread (279 cm) and biomass yield (296 kg/ha ) was found to be statistically significant with Amla intercropped with field bean compared with sole amla. The higher amla equivalent yield was recorded in intercropping with finger millet (1517 kg/ha) and was at par with cowpea (1298 kg/ha). Finger millet proved to be better intercrop in amla and registered 57.11 per cent higher net returns and Benefit cost ratio than sole amla. Overall, Amla + finger millet cropping system was found to be more sustainable both in terms of benefit cost ratio (2.43) and improving system productivity (104.44 %) followed by pulse crop such as cowpea and field bean. The higher sustainable yield index (0.83) was with amla + finger millet intercropping system while Land Equivalent Ratio and Area Time Equivalent Ratio were higher with amla + field bean intercropping system.

**Introduction**

Climate change induced an unsustainable production system under rainfed situation, demands climate smart crops (Ramachandrappa *et al.*, 2016a; Bhutiani and Ahamad, 2018) combating climate change demands enhancing forest ecosystem, which is difficult to increase under populated India. Alternate land use involving Agri- horti systems seems to the long term operation for sustainability. Amla or Indian goose berry (*Emblica officinalis* L.) based agri-horticultural system has enormous potential to use and conserve rainfall particularly under dryland condition for betterment of poor farmers (Thimmegowda *et al.*, 2019). Amla is an
deep rooted deciduous tree species, which has a wide adaptability in wider range of soil. It is potential fruit species suitable for growing under dryland condition. Sole amla orchards provides gives higher gross returns with lesser investments for planting and its management, but taking agricultural crops as intercrops along with amla provides an opportunity for better land utilization also reduction in the risk due to aberrant climate condition.

Agri horticulture systems in rainfed conditions are the ideal systems for controlling runoff, soil erosion and land degration. The major problem in rainfed area is increased competition between trees and crops for water. But the varied nature of crops in agri-horti system, utilize the water as well as other resource efficiently with added seasonal revenue. Intercropping has been proved as potential crop production systems and it will provide substantial yield advantage over sole cropping system (Willey, 1979).

Intercropping systems have ability to cover land surface very efficiently, which check soil erosion and helps to check soil erosion through sufficient ground coverage and also improve the soil physico-chemical condition. Traditionally, intercropping in the interspaces of fruit orchards is practiced (Adiveppa Mallappa Asangi et al, 2019), but only a few results are available for amla based horticultural system. Hence, the present study was undertaken to know the suitability and profitability aspects of different intercrops under rain-fed conditions in Alfisols of semiarid tropic.

Material and Methods

Study area: The field study was carried out at the AICRP for Dryland Agriculture, University of Agricultural Sciences, Bengaluru. The centre is situated in Eastern Dry Zone of Karnataka at 12° 58’ North latitude and 77° 35’ East longitude with altitude of 930 m above mean sea level. The site experiences climate with bimodal distribution of rainfall i.e. the rainfall during 2014 and 2015 was positive normal with 8.6 and 15.9 per cent excess higher values. The deviation during kharif 2013 and 2016 was -7.4 and -24.5 %, respectively compared to normal and the impact on crop production activities under conventional farming practices was more pronounced during 2016 (Table 1).

The intercropping trial was carried out in well-established five year old amla orchards for seven years from 2011-12 to 2017-18.

Treatment details: The intercrops considered in the study are finger millet, cowpea, horsegram, field bean, fodder maize and grain amaranth besides their sole crop and compared with amla. The intercrops were sown one meter away from the trunk. The experiment was laid out in a Randomized Block design with three replications. Well decomposed compost 15 t ha⁻¹ was applied well before 15 days prior to sowing of the intercrops. Nitrogen, phosphorus and potassium were applied as basal doses @ 50:40:25 kg ha⁻¹ for finger millet, 25:50:25 kg ha⁻¹ for cowpea and field bean, 25:38:25 kg ha⁻¹ for horsegram, 100:50:25 kg ha⁻¹ for fodder maize and 40:20:20 kg ha⁻¹ for grain amaranth. In case of finger millet, fodder maize and grain amaranth. Nitrogen was applied in two equal splits one as basal dose and at 30 DAS. The soil of the experimental site was acidic in reaction [pH(1:2.50): 5.4], deficient in organic carbon (0.32 %), medium in available N (372.8 kg ha⁻¹), P₂O₅ (49 kg ha⁻¹) and K₂O (169.9 kg ha⁻¹).Observations on growth parameters of amla in terms of plant
height, number of branches per plant and crown diameter were recorded. The data on fruit yield per plant were recorded at harvest during all four years and were statistically analyzed, similarly the intercrops yield was also recorded. The yield of intercrop was converted into amla equivalent yield considering the yield and prevailing price of the produce (Thimmegowda et al., 2016).

\[
\text{Crop equivalent yield (kg/h)} = \left( \frac{\text{Yield of inter crop (kg/ha)} \times \text{Price of inter crop (Rs/kg)}}{\text{Price of main crop (Rs/kg)}} \right) + \left( \frac{\text{Yield of main crop (kg/ha)}}{Y_{\text{max}}} \right)
\]

Where,
- \(Y_{\text{ab}}\): Intercropping yield of crop a
- \(Y_{\text{ba}}\): Intercropping yield of crop b
- \(Y_{\text{aa}}\): Sole yield of crop a
- \(Y_{\text{bb}}\): Sole yield of crop b
- \(Y_{\text{max}}\): Maximum yield obtained in any of the treatments over the years.

The economics was calculated for individual treatments for all the years by respective price of inputs and produce. The net return received during study was worked out by subtracting cost of cultivation (Rs/ha) from the gross return (Rs/ha) of respective years.

**Statistical analysis:** The data from 7 years were analyzed to check the significant difference between the treatments and to draw valid conclusions with Analysis of Variance technique (Gomez and Gomez, 1984. The level of significance used in ‘F’ and ‘t’ test was p=0.05. Critical difference (CD) values were calculated, wherever ‘F’ test was found significant.

**Results and Discussion**

**Growth Parameters of amla**

**Plant height, Number of branches and Collar diameter:** Inter crops grown in association with amla varied significantly for different parameters. The plant height, branches and collar growth are the important attributes, which greatly influenced by supply of water and nutrient. The increased plant population per unit area due to addition of intercrops resulted in higher competition for soil moisture, nutrients and light, which influenced the vertical/ horizontal growth and intern growth parameters. Amla + field bean recorded significantly higher plant height (369 cm), number of branches (2.66) and collar diameter (35.31 cm) followed by amla + cowpea, amla+ horsegram compared to amla sole (309, 2.26, 31.03 cm, respectively) (Table 2). The higher growth parameters are mainly attributed due to enhanced availability of nitrogen through symbiotic nitrogen fixation and increased organic matter addition in the form of leaf litter by the legume crops. Due to higher biomass production, incorporation and further decomposition has led to higher availability of nutrients for uptake (Adiveppa Mallappa Asangi et al., 2019). The increase in stem collar diameter could also be due to increase in leaf canopy spread, number of leaves and number of branches. These results are in conformity with the findings of Chauhan et al. (2013), Ramulu et al. (2015) and Swain et al. (2014).
Canopy spread/plant and biomass (kg/tree): At harvest, the canopy spread of amla differed significantly due to intercropping. Amla + field bean recorded higher canopy spread/plant (279 cm) followed by amla + cowpea (250 cm). Significantly lower canopy was recorded by amla + fodder maize (197.2 cm) (Table 3). Higher biomass (kg/tree) was noticed in amla + field bean (296 kg/tree) followed by amla + horse gram (286 kg/tree) as compared to other intercrops (Table 3). Enhanced growth of amla plants in with intercrops might have attributed to the improved soil porosity and aeration from frequent soil management practices and also due to the better response for applied inputs by intercrops than in sole plantation. Interspaces of sole crops were left uncultivated and not received additional inputs like manure, fertilizer etc., Awasthi and Saroj (2004) reported positive effect of intercrops on growth and vigour of amla and mango. The finding also supports the views of Saroj et al. (2003) in ber.

Yield of Amla as influenced by intercrops

Amla yield: Among the different intercrops, higher amla fruit yield (749 kg/ha) was recorded from the amla trees inter cropped with field bean, while it was minimum in fodder yield (535 kg/ha) followed by 721 kg/ha in amla + cowpea, 655 kg/ha in Amla + horse gram and 604 kg/ha in amla + finger millet than amla + fodder maize (535 kg/ha) and sole amla (655 kg/ha) (Table 5). Growing of pulse crop helped in building up of soil fertility and better utilization of applied nutrients which resulted in improved growth and yield of main crop (Meena et al., 2011). Maize being an exhaustive crop removed much nutrients for its growth and yield and there by resulted in reduced yield of amla (Chaturvedi and Jha, 1998). The other reason for increase in fruit production under agri-horticultural system may be also due to application of fertilizers and manure to intercrops and its utilization by amla trees as there was no physical barrier between root systems of intercrops and trees (Korwar et al., 2006).

Amla equivalent yield: Significantly higher amla equivalent yield was observed in intercropping with finger millet (1517 kg/ha) followed by cowpea (1298 kg/ha) and field bean (1235 kg/ha) compared to other intercrops in amla based agri-horti system (Table 6). Better performance of small millet even under drought and erratic rainfall both as sole and intercrop during the different growing period over the years was due to their drought tolerance (Shashidhar et al., 2000). With respect to legume as intercrops which act as good cover crop and helps in better moisture conservation helped in yield enhancement

Intercropping efficiency

On the basis of mean data among different intercrops, maximum land equivalent ratio was recorded with amla + field bean (1.69) followed by amla + finger millet (1.61) intercropping system, indicating more efficient use of land than sole amla and among the intercrop less land equivalent ratio was recorded in amla + fodder maize (1.46) (Figure 1). Intercropping efficiency analysis using the ATER approach has also shown differences among different associations (Figure 1). The higher mean values of ATER were recorded by the Amla + field bean (1.67) intercropping system. While, the lowest ATER value was recorded by the alma + finger millet (1.06). The higher yield were recorded in intercrops was mainly due to complementary effects among component crops and also due to efficient use of resources when compared to sole cropping systems (Mudalagiriyappa et al., 2011). The inherent capacity of crops will efficiently utilize natural resources and complementary interaction plays vital role in resource utilization (Maitra et al., 2019). Further, higher yield of both the crops in maize-cowpea intercropping combination was noted than pure stands (Kimou et al., 2017).
Table 2: Plant height (cm), No of branches and stem diameter (cm) of amla as influenced by amla based Agri-horti system

| Treatment                  | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | Pooled |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|--------|
| **Plant height (cm)**      |         |         |         |         |         |         |         |        |
| Amla+Finger millet         | 163     | 236     | 240     | 304     | 357     | 350     | 345     | 285    |
| Amla+Fodder maize          | 174     | 254     | 248     | 334     | 355     | 365     | 359     | 299    |
| Amla+Field bean            | 204     | 289     | 341     | 357     | 388     | 506     | 500     | 369    |
| Amla+Grain amaranth        | 188     | 255     | 239     | 301     | 320     | 328     | 329     | 280    |
| Amla+Cowpea                | 164     | 253     | 313     | 342     | 381     | 444     | 439     | 334    |
| Amla+Hordegram             | 190     | 263     | 341     | 349     | 376     | 482     | 476     | 354    |
| Amla sole                  | 151     | 172     | 207     | 342     | 380     | 457     | 452     | 309    |
| S. Em. ±                   | 5.89    | 15.76   | 15.14   | 20.24   | 22.60   | 34.47   | 34.07   | 29.59  |
| C. D. (p=0.05)             | 18.14   | 48.56   | 46.64   | NS      | NS      | 106.23  | 104.99  | 83.07  |
| **No. branches**           |         |         |         |         |         |         |         |        |
| Amla+Finger millet         | 1.77    | 2.20    | 2.11    | 2.83    | 2.83    | 2.33    | 2.67    | 2.39   |
| Amla+Fodder maize          | 2.10    | 2.30    | 2.58    | 3.00    | 3.00    | 3.00    | 2.67    | 2.66   |
| Amla+Field bean            | 3.30    | 2.77    | 2.83    | 3.10    | 3.10    | 2.00    | 2.00    | 2.73   |
| Amla+Grain amaranth        | 2.80    | 2.90    | 2.33    | 3.00    | 3.00    | 2.33    | 2.33    | 2.67   |
| Amla+Cowpea                | 1.90    | 2.20    | 2.57    | 3.07    | 3.07    | 2.67    | 3.33    | 2.69   |
| Amla+Hordegram             | 2.40    | 2.77    | 2.58    | 3.00    | 3.00    | 1.67    | 2.33    | 2.54   |
| Amla sole                  | 1.60    | 1.43    | 1.98    | 3.07    | 3.07    | 2.33    | 2.33    | 2.26   |
| S. Em. ±                   | 0.12    | 0.17    | 0.13    | 0.08    | 0.08    | 0.56    | 0.36    | 0.28   |
| C. D. (p=0.05)             | 0.37    | 0.52    | 0.41    | NS      | NS      | NS      | NS      | 0.77   |
| **Stem diameter (cm)**     |         |         |         |         |         |         |         |        |
| Amla+Finger millet         | 12.6    | 21.0    | 21.8    | 31.5    | 32.3    | 43.8    | 44.7    | 29.66  |
| Amla+Fodder maize          | 12.8    | 24.2    | 25.9    | 37.8    | 38.2    | 43.7    | 42.7    | 32.19  |
| Amla+Field bean            | 15.2    | 26.9    | 32.3    | 38.5    | 42.1    | 45.5    | 46.7    | 35.31  |
| Amla+Grain amaranth        | 15.0    | 25.4    | 22.6    | 32.0    | 35.1    | 43.3    | 42.0    | 30.79  |
| Amla+Cowpea                | 12.8    | 24.2    | 28.9    | 38.3    | 42.0    | 41.8    | 43.0    | 33.02  |
| Amla+Hordegram             | 14.8    | 24.4    | 28.2    | 38.2    | 40.2    | 46.3    | 47.3    | 34.22  |
| Amla sole                  | 10.7    | 19.5    | 20.9    | 38.8    | 40.8    | 43.7    | 43.0    | 31.03  |
| S. Em. ±                   | 0.62    | 1.18    | 1.26    | 2.09    | 4.08    | 2.73    | 2.67    | 2.34   |
| C. D. (p=0.05)             | 1.92    | 3.64    | 3.87    | NS      | NS      | NS      | NS      | 6.58   |

*NS: Non-significant at p=0.05
Table 3: Canopy spread and biomass of amla as influenced by amla based Agri-horti system

| Treatment               | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | Pooled |
|-------------------------|---------|---------|---------|---------|---------|---------|---------|--------|
| **Canopy spread (cm)**  |         |         |         |         |         |         |         |        |
| Amla + Finger millet    | 90      | 153     | 146     | 179     | 302     | 346     | 349     | 223    |
| Amla + Fodder maize     | 106     | 152     | 156     | 207     | 282     | 307     | 307     | 217    |
| Amla + Field bean       | 118     | 192     | 199     | 302     | 338     | 402     | 404     | 279    |
| Amla + Grain amaranth   | 109     | 189     | 152     | 185     | 290     | 318     | 318     | 223    |
| Amla + Cowpea           | 101     | 153     | 190     | 265     | 313     | 365     | 362     | 250    |
| Amla + Horsegram        | 108     | 155     | 182     | 243     | 306     | 343     | 346     | 240    |
| Amla sole               | 78      | 131     | 106     | 304     | 308     | 404     | 396     | 247    |
| **SEm±**                | 3.50    | 15.86   | 6.62    | 9.57    | 22.20   | 14.98   | 12.56   | 13.43  |
| **CD (0.05)**           | 10.79   | NS      | 20.40   | 29.50   | NS      | 46.15   | 38.69   | 37.70  |
| **Amla biomass (kg/ha)**|         |         |         |         |         |         |         |        |
| Amla+Finger millet      | 78      | 150     | 158     | 386     | 264     | 386     | 395     | 259    |
| Amla+Fodder maize       | 80      | 180     | 197     | 384     | 323     | 384     | 367     | 273    |
| Amla+Field bean         | 99      | 206     | 261     | 326     | 366     | 405     | 409     | 296    |
| Amla+Grain amaranth     | 97      | 192     | 165     | 258     | 291     | 380     | 362     | 249    |
| Amla+Cowpea             | 80      | 180     | 226     | 325     | 365     | 363     | 373     | 273    |
| Amla+Horsegram          | 96      | 182     | 219     | 323     | 348     | 415     | 419     | 286    |
| Amla sole               | 63      | 136     | 149     | 329     | 353     | 385     | 380     | 256    |
| **SEm±**                | 5.1     | 11.1    | 12.4    | 22.0    | 43.5    | 30.8    | 29.8    | 25.2   |
| **C. D. (p=0.05)**      | 15.6    | 34.3    | 38.1    | 67.7    | NS      | NS      | NS      | 70.8   |

*NS: Non-significant at p=0.05
Table 4: Intercrop yield as influenced by amla based Agri-horti system

| Treatment                  | Intercrop yield (kg/ha) |
|----------------------------|-------------------------|
|                            | 2011 | 2012 | 2013 | 2014 | 2015 | 2017 | Mean |
| Amla + Finger millet       | 2610 | 1843 | 2187 | 2296 | 1746 | 1324 | 1620 |
| Amla + Fodder maize        | 17989| 12332| 9840 | 7691 | 18057| 13902| 7825 |
| Amla + Field bean          | 887 | 725 | 953 | 595 | 334 | 308 | 490 |
| Amla + Grain amaranth      | 1287 | 1106 | 948 | 783 | 267 | 261 | 555 |
| Amla + Cowpea              | 810 | 737 | 856 | 498 | 473 | 398 | 450 |
| Amla + Horsegram           | 653 | 587 | 831 | 526 | 247 | 221 | 421 |
| Finger millet              | 2576 | 1872 | 2424 | 2679 | 2167 | 2033 | 2292 |
| Fodder maize               | 27683| 13846| 10758| 17727| 23070| 18974| 18676|
| Field bean                 | 947 | 769 | 1970 | 776 | 587 | 557 | 768 |
| Grain amaranthus           | 1413 | 1295 | 1152 | 958 | 412 | 349 | 930 |
| Cowpea                     | 877 | 795 | 924 | 727 | 935 | 808 | 844 |
| Horsegram                  | 703 | 615 | 1030 | 697 | 424 | 405 | 646 |

*In 2016 due to scanty rainfall intercrop was not recorded.

Table 5: Amla yield as influenced by amla based Agri-horti system

| Treatment                  | Amla yield (kg/ha) |
|----------------------------|-------------------|
|                            | 2013  | 2014  | 2015  | 2016  | 2017  | Pooled |
| Amla + Finger millet       | 407   | 411   | 776   | 728   | 699   | 604    |
| Amla + Fodder maize        | 379   | 399   | 577   | 591   | 730   | 535    |
| Amla + Field bean          | 449   | 470   | 1045  | 914   | 867   | 749    |
| Amla + Grain amaranth      | 338   | 386   | 711   | 699   | 716   | 570    |
| Amla + Cowpea              | 422   | 453   | 1012  | 861   | 858   | 721    |
| Amla + Horsegram           | 458   | 425   | 816   | 838   | 739   | 655    |
| Amla sole                  | 476   | 509   | 999   | 846   | 879   | 742    |
| S. Em. ±                   | 16.90 | 25.39 | 60.22 | 78.92 | 51.49 | 49.16  |
| C. D. (p=0.05)             | 52.07 | NS    | 185.55| NS    | NS    | 138.72 |

*NS: Non-significant at p=0.05
Table 6: Amla equivalent yield as influenced by amla based Agri-horti system

| Treatment                  | Amla Equivalent yield (kg/ha) | SYI |
|----------------------------|-------------------------------|-----|
|                            | 2013  | 2014  | 2015  | 2016  | 2017  | Pooled |       |
| Amla+Finger millet         | 1849  | 1845  | 1736  | 728   | 1427  | 1517   | 0.83  |
| Amla+Fodder maize          | 858   | 591   | 1254  | 591   | 1251  | 912    | 0.43  |
| Amla+Field bean            | 1255  | 1214  | 1504  | 914   | 1290  | 1235   | 0.64  |
| Amla+Grain amaranth        | 825   | 1561  | 1112  | 699   | 1108  | 1061   | 0.53  |
| Amla+Cowpea                | 1903  | 1076  | 1604  | 861   | 1355  | 1298   | 0.68  |
| Amla+Horsegram             | 1264  | 846   | 1032  | 838   | 932   | 982    | 0.48  |
| Amla sole                  | 476   | 509   | 999   | 846   | 879   | 742    | 0.32  |
| S. Em. ±                   | 51.88 | 97.68 | 57.81 | 56.34 | 60.35 | 67.22  |       |
| C. D. (p=0.05)             | 151.42| 285.10| 168.73| 164.43| 176.16| 188.00 |       |

*S: Non-significant at p=0.05

Figure 1. Land equivalent ratio and Area time equivalent ratio of amla as influenced by amla based Agri-horti system.
Table 7: Net returns and B: C ratio of amla as influenced by amla based Agri-horti system

| Treatment                  | Net returns (Rs./ha) | B: C ratio |
|----------------------------|----------------------|------------|
|                            | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | Mean  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | Mean  |
| Amla + Finger millet       | 18400 | 20618 | 29831 | 51632 | 43110 | 10824 | 29446 | 29123 | 2.38  | 2.27  | 2.74  | 3.33  | 2.64  | 1.59  | 2.07  | 2.43  |
| Amla + Fodder maize        | 13300 | 9321  | -2726 | 2573  | 28499 | 5591  | 28737 | 12185 | 2.21  | 1.73  | 0.90  | 1.12  | 2.31  | 1.31  | 2.13  | 1.67  |
| Amla + Field bean          | 3300  | 1310  | 9210  | 23570 | 34548 | 19037 | 24332 | 16472 | 1.51  | 1.17  | 1.32  | 1.94  | 2.35  | 2.09  | 2.88  | 1.89  |
| Amla + Grain amaranth      | 14300 | 8939  | -2687 | 38665 | 18736 | 13635 | 25212 | 16686 | 2.16  | 1.70  | 0.90  | 2.63  | 1.73  | 1.95  | 1.96  | 1.86  |
| Amla + Cowpea              | 1628  | 1197  | 29548 | 18867 | 39917 | 16794 | 27824 | 19396 | 1.10  | 1.07  | 2.07  | 1.78  | 2.65  | 1.95  | 2.25  | 1.84  |
| Amla + Horsegram           | 5650  | 2590  | 11994 | 11513 | 28876 | 17914 | 18501 | 13863 | 1.41  | 1.19  | 1.46  | 1.52  | 3.33  | 2.15  | 1.72  | 1.83  |
| Amla sole                  | -     | -     | 6537  | 9958  | 29094 | 23039 | 24053 | 18536 | -     | -     | 1.79  | 3.68  | 2.82  | 3.14  | 3.16  | 2.91  |
Sustainable yield index (SYI)
The data given in Table 6 revealed that amla + finger millet intercropping system recorded the higher sustainable yield index (0.83) followed by amla + cowpea (0.68) and amla + amla + field bean (0.64) as compared to sole amla (0.32) which indicated that at least 159 per cent of the maximum observed yield over years is assured with high probability in intercropping system as against 159 per cent in sole cropping system. Hence, higher sustainable yield index shows that the intercropping helps in providing yield stability (Henry and Kumar, 2005). Similar findings were reported by Koli et al. (2004). Finger millet was found to be a compatible intercrop with amla for efficient use of resources and sustainability under dryland situations.

Economics
Economic analysis of different intercropping system showed that higher returns were obtained when the intercrops were grown in association with amla compared to sole cropping. Finger millet intercropping in amla earned maximum net returns (Rs. 29,123/ha) followed by amla + cowpea (Rs. 19,396/ha). These two intercrops estimated an additional income of Rs. 10,587/ha and 860/ha, respectively over sole amla. Lower returns obtained from other intercropping system was due to lower prevailing market price and increased cost on amla in all other treatments. Similar was the trend in B:C ratio with 2.13 in amla + finger millet with 104.44 % improvement in system productivity compared to other inter crops (Table 7). The increased returns from tree-crop combination have been reported by Nath et al. (2007) in perennial fruit based multi storied production system

Conclusion
Agri-horticulture system is an essential approach to have higher farm income and for maintaining better soil fertility. Even though the yield of individual crops including amla was higher under sole crops but the additional yield from component crops is an added advantage under intercropping system. Amla trees intercropped with finger millet was better cropping system, since it has recorded 104.47 per cent higher finger equivalent yield, higher net returns, inter cropping efficiency and sustainable yield index when compared to sole amla. Besides finger millet, pulses like cowpea and field bean are also best intercrops in amla to get higher yield, profit and sustainability.

Conflict of interest
The authors declare that they have no conflict of interest.
Growth, yield and economics of amla (Emblica officinalis L.) based

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