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# Performance of component crops in tree-crop farming system under arid region

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## ABSTRACT

**Variations were recorded in growth and yield performances of trees as well as annual crops grown in combination under tree-crop farming. Plant growth and yield of all component crops were higher when grown under conjugation as compared to their sole croppings. Under integrated model, there was 50-53% increase in yield (84.60 to 86.52 q/ha) of *ber* over its sole cropping (56.32 q/ha). Allelo-chemical study revealed negative response of leaf extract of tree crops on germination and growth parameters of seedlings of annual crops. However, *karonda* leaf extract exhibited positive response on seedling germination and growth parameters of mustard (germination 93.3% as against 86.6% in control) and also of brinjal (germination 93.3% as against 88.3% in control).**

**Key words:** Growth, yield, annual crops, tree crops, allelo-chemicals.

## INTRODUCTION

With intensification of farming practices, the nature and natural resources are deteriorating and also growth rate in agriculture witnessing a decline (Singh, 16). Hastening greenhouse effect, deviating rainfall, deteriorating soil, stagnating yield, escalating pressure on land etc. are viewed seriously in view of safeguarding over all interest of earth dwellers. Agroforestry options inducting trees along with crops are fast emerging scenario especially in fragile agro-ecology where the recurrence of crop failure is very high. The utility of tree crop farming in arid region has been highlighted by Shankaranarayan *et al*. (15). However, it is a belief amongst the farming community that growing of crops in combination of trees influences crop yield. This is accounted to the presence of chemicals often called allelo-chemicals (Barbour *et al*., 4), no doubt it happens, but simultaneously, it has beneficial effect too under certain combinations. There are combinations of tree and crops, which interact complementarily rather competitively in affecting growth and production. In present investigation an attempt has been made to study the performance in terms of growth and yield of all component crops as observed under different tree-crop combinations under arid region of Rajasthan alongwith allelochemy study made under laboratory conditions.

## MATERIALS AND METHODS

The field experiment was conducted at the Central Institute for Arid Horticulture, Bikaner, Rajasthan in the tree fruit orchards planted during 2003. Bikaner is located at an altitude of 234.7 m above msl and latitude of 28°01' N and longitude of 73°22' E. The soil of the experimental site was sandy loam, poor in fertility and water holding capacity with pH 8.4, organic carbon 0.09 per cent, available nitrogen 110 kg per ha, available phosphorus 4 kg per ha and available potassium 224 kg per ha. Integrating tree and crop suitably along with growing them as a sole, there were 11 treatments- $T_1$ = *aonla* + *ber* + *karonda* + cluster bean (*kharif*) + brinjal (*rabi*); $T_2$ = *aonla* + *ber* + *karonda* + cluster bean (*kharif*) + fallow; $T_3$ = *aonla* + *ber* + *karonda* + moth bean (*kharif*) + mustard (*rabi*); $T_4$ = *aonla* + *ber* + *karonda* + moth bean (*kharif*) + fallow; $T_5$ = *aonla* sole; $T_6$ = *ber* sole; $T_7$ = *karonda* sole; $T_8$= cluster bean sole; $T_9$ = moth bean sole; $T_{10}$ = brinjal sole and $T_{11}$ = mustard sole. All treatments were replicated in quadruplicate. In the experimental field, the tree fruits had the stands maintained at the spacing of 8 m x 8 m and the annual crops were grown over 32 $m^2$ area in spaces in between fruit trees. The detail of cultivars, number of plants, spacing, crops arrangement in respect to tree fruits and the component annual crops are furnished in Table 1. Annual crops, namely, cluster bean and moth bean were raised during *kharif*, while mustard and brinjal were raised during *rabi* season, 2006-07. Crops were harvested at their respective maturity stages. Data pertaining to growth and yield attributes of both annual and tree crops were recorded. Allelo-chemical response of tree fruits on component annual crops were also attempted to study following application of mature leaf extract to seeds of component annual crops grown under laboratory conditions. The test of significance among various treatment combinations was adjudged using randomized block design. While,

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**Table 1.** Arrangement of tree fruits and annual crops under tree-crop farming system.

| Name of crop | Cultivar | No. of plants | Spacing | Remarks |
|---|---|---|---|---|
| Tree fruits- the top storey component* | | | | |
| *Aonla* (*Emblica officinalis*) | NA-7 | 04 | 8 × 8 $m^2$ | Top storey component |
| *Ber* (*Zizyphus mauritiana*) | Seb | 01 | 8 × 8 $m^2$ | Planted as filler between four *aonla* plants |
| *Karonda* (*Carissa congesta*) | Maroon Red | 04 | 3 × 3 $m^2$ | Planted in intra- row spacing of *aonla* |
| Annual crops- the ground storey component** | | | | |
| Cluster bean (*Cyamopsis tetragonoloba*) (*kharif*) | RGC-936 | 266 | 60 × 20 $cm^2$ | Sown in inter-spaces of *aonla-ber* and *karonda* plants |
| Brinjal (*Solanum melongena*) (*rabi*) | Local | 88 | 60 × 60 $cm^2$ | Sown in inter-spaces of *aonla-ber* and *karonda* plants |
| Moth bean (*Phaseolus acontifolius*) (*kharif*) | RMO-40 | 1066 | 30 × 10 $cm^2$ | Sown in inter spaces of *aonla-ber* and *karonda* plants |
| Mustard (*Brassica juncea)* (*rabi*) | Bio-902 | 1066 | 30 × 10 $cm^2$ | Sown in inters-paces of *aonla-ber* and *karonda* plants |

*Tree fruits in combination-Top storey- *aonla*, middle storey- *ber* and bottom storey- *karonda*. Tree fruits were distributed over 64 $m^2$ area.

**annual crops were distributed over 32 $m^2$ area in inter-spaces of *aonla-ber* and *karonda* plants.

the test of significance in data pertaining to allelochemy was worked out using factorial complete randomized design (CRD).

## RESULTS AND DISCUSSION

The observation pertaining to growth performance of tree fruits is presented in Table 2. While discussing the growth parameters of tree fruits (*aonla*, *ber* and *karonda*), initial observation recorded before commencement of experiment as presented in Table 1, has been compared suitably to draw inferences. The maximum plant height in respect of all tree fruits were recorded in $T_1$- *aonla* + *ber* + *karonda* + cluster bean + brinjal . However, in case of plant height of *aonla*, it was maximum in $T_2$ - *aonla* + *ber* + *karonda* + cluster bean + fallow. As compared to sole stand, heights of *aonla* and *ber* were maximum, when grown under integrated models along with annual crops. Whereas, in *karonda* the height of sole stand of *karonda* was maximum over $T_3$ - *aonla* + *ber* + *karonda* + moth bean + fallow and $T_4$ - *aonla* + *ber* + *karonda* + moth bean + fallow.

The yield data of all tree fruits recorded in different integrated models are presented in Table 2. Comparative evaluation of the data presented in the table revealed that the fruit yields of *aonla*, *ber* and *karonda* were significantly higher in all the integrated cropping models as compared to their sole crops. In case of *aonla*, fruit yield varied between 7.73 to 8.04 q per ha. Fruit yield in *aonla* increased by 212.84 per cent in $T_3$ - *aonla* + *ber* + *karonda* + moth bean + fallow to 200.77 per cent in $T_4$ - *aonla* + *ber* + *karonda* + moth bean + fallow over $T_5$ - *aonla* (sole). Almost similar trend was observed in case of *ber* in which the yield varied between 84.60 q per ha in $T_4$ - *aonla* + *ber* + *karonda* + moth bean + fallow to 86.52 q per ha. Per cent increase in fruit yield was comparatively lower than *aonla* but as compared to sole crop, it was higher by 53.59 per cent in $T_3$- *aonla* + *ber* + *karonda* + moth bean + fallow. In rest of the tree-crop integrated models, a general increase of 50 per cent was recorded. In *karonda*, slightly different trend in fruit yield was needed. It was recorded minimum in $T_3$ - *aonla* + *ber* + *karonda* + moth bean + fallow (43.59 q per ha). In the other integrated cropping models, it varied between 43.74 q per ha ($T_1$ - *aonla* + *ber* + *karonda* + cluster bean + brinjal) to 44.06 q per ha ($T_2$ - *aonla* + *ber* + *karonda* + moth bean + mustard). Fruit yield in *karonda* increased by 123.88 per cent in $T_2$ *aonla* + *ber* + *karonda* + moth bean + mustard to 121.49 per cent in $T_3$ - *aonla* + *ber* + *karonda* + moth bean + fallow over sole crop.

Data pertaining to growth parameters of cluster bean, moth bean, mustard and brinjal grown during their respective seasons pertaining to plant height and number of branches per plant recorded at crop maturity are presented in Table 3. Maximum plant height (94.5 cm) of cluster bean was recorded in $T_1$ - *aonla* + *ber* +

**Table 2.** Growth differential and yield of fruits plants under tree-crop farming system.

| Treatment | Plant height (cm) at initiation | | | Plant height (cm) at the termination | | | Yield (q/ ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Aonla* | *Ber* | *Karonda* | *Aonla* | *Ber* | *Karonda* | *Aonla* | *Ber* | *Karonda* |
| $T_1$ - *Aonla* + *ber* + *karonda* + cluster bean + brinjal | 67.67 | 184.55 | 80.72 | 96.45 | 269.10 | 105.10 | 8.00 | 85.03 | 43.74 |
| $T_2$ - *Aonla* + *ber* + *karonda* + cluster bean+ fallow | 67.05 | 182.26 | 78.92 | 101.40 | 267.75 | 99.80 | 7.81 | 84.68 | 44.06 |
| $T_3$ - *Aonla* + *ber* + *karonda* + moth bean+ mustard | 56.02 | 175.62 | 62.82 | 88.20 | 262.75 | 90.77 | 8.04 | 86.52 | 43.59 |
| $T_4$ *Aonla* + *ber* + *karonda* + moth bean + fallow | 64.19 | 181.65 | 72.07 | 77.13 | 265.00 | 82.42 | 7.73 | 84.60 | 43.90 |
| $T_5$ - *Aonla* (sole) | 41.85 | - | - | 69.62 | - | - | 2.57 | - | - |
| $T_6$ - *Ber* (sole) | - | 141.20 | - | - | 209.90 | - | - | 56.32 | - |
| $T_7$ - *Karonda* (sole) | - | - | 63.50 | - | - | 92.30 | - | - | 19.68 |
| $CD_{0.05}$ | 4.25 | 6.42 | 3.02 | 5.90 | 9.04 | 3.12 | 0.83 | 4.08 | 2.84 |

**Table 3.** Growth and yield parameters of annual crops under tree-crop farming system.

| Treatment# | Plant height (cm) | | | | No. of branches per plant | | | | Yield (q/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CB* | MB** | Mustard*** | Brinjal**** | CB | MB | Mustard | Brinjal | CB (pod) | MB (pod) | Mustard (silique) | Brinjal (fruit) |
| $T_1$ | 94.5 | - | - | 67.6 | 6.45 | - | - | 13.40 | 8.25 | - | - | 81.75 |
| $T_2$ | 93.02 | - | - | - | 6.00 | - | - | - | 7.22 | - | - | - |
| $T_3$ | - | 26.83 | 144.9 | - | - | 5.52 | 6.31 | - | - | 3.99 | 14.0 | - |
| $T_4$ | - | 25.35 | - | - | - | 5.45 | - | - | - | 4.25 | - | - |
| $T_8$ | 87.06 | - | - | - | 5.15 | - | - | - | 6.60 | - | - | - |
| $T_9$ | - | 22.96 | - | - | - | 4.65 | - | - | - | 3.57 | - | - |
| $T_{10}$ | - | - | - | 64.3 | - | - | - | 12.82 | - | - | - | 64.00 |
| $T_{11}$ | - | - | 146.5 | - | - | - | 6.85 | - | - | - | 15.01 | - |
| CV % | 3.80 | 12.89 | 2.48 | 3.69 | 7.70 | 7.09 | 3.31 | 1.01 | 9.66 | 10.74 | 9.44 | 11.18 |

# $T_1$= *Aonla* + *ber* + *karonda* + cluster bean + brinjal, $T_2$ = *Aonla* + *ber* + *karonda* + cluster bean+ fallow, $T_3$= *Aonla* + *ber* + *karonda* + moth bean + mustard, $T_4$= *Aonla* + *ber* + *karonda* + moth bean + fallow, $T_8$ = Cluster bean (sole), $T_9$ = Moth bean (sole), $T_{10}$ = Brinjal (sole), $T_{11}$ = Mustard (sole)

*karonda* + cluster bean + brinjal, while it was recorded to be minimum (87.06 cm) in sole cluster bean ($T_8$). Similar trend was observed in moth bean and brinjal where the plants heights were superior in integrated cropping models as compared to their sole cropping. However, the plant height of mustard was recorded to be more in case of sole crop ($T_{11}$ - mustard sole) as compared to the plant height in integrated model ($T_3$ - *aonla* + *ber* + *karonda* + moth bean + mustard). Data presented in Table 3 revealed that the number of branches per plant of different annual crops did not differ much between different crop combinations and their sole cropping. However, higher number of branches per plant was recorded in cluster bean, moth bean and brinjal when grown as companion component over their sole crop except mustard, where the number of branches per plant were recorded to be slightly higher (6.85) in sole cropping than those grown in association with *aonla* + *ber* + *karonda*.

The yield parameters, *viz*., number of pods/ silique/ fruits per plant and yield per ha recorded at the time of harvesting of the crops is presented in the Table 3. From the data it is apparent that the annual crops, when grown under integration, produced higher number of pods/ silique/ fruits per plant except mustard where a reverse trend was recorded. It is evident from the result that yields of all annual crops were higher when grown in association with tree fruits as compared

to their sole cropping. The average increase in grain yield of cluster bean in integrated cropping model was of the order of 25 and 9.39 per cent over its sole crop. In moth bean, it increased by 11.76 and 19.04 per cent in $T_3$ - *aonla* + *ber* + *karonda* + moth bean + mustard and $T_4$ - *aonla* + *ber* + *karonda* + moth bean + fallow. However, in case of mustard when grown as sole crop, higher yield was obtained. In case of companion cropping with *aonla-ber-karonda*, a reduction in grain yield of 7.21 per cent in cluster bean was recorded. Brinjal grown as ground storey crop during *rabi* season in tree crop integrated model produced 27.73 per cent more yield than sole crop.

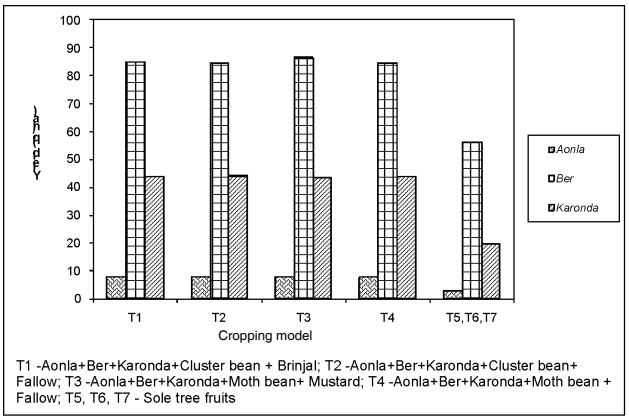
Allelo-chemical influence of aqueous leaf extracts of tree crops on seasonal crops are presented in Table 4. Leaf extracts of *aonla* and *ber* reduced the germination of seeds of cluster bean, moth bean, mustard and brinjal. There was 84.64% reduction in germination (13.3% as against 86.6% in control) in mustard following the use of leaf extract of *aonla*. The *ber* leaf extracts reduced germination of mustard by 73.09% (germination 23.3% as against 86.6% in control). The leaf extract of *karonda* hastened germination of seeds of mustard and brinjal, while it reduced the germination of cluster bean and moth bean. Similar negative effects of leaf extracts of *aonla*, *ber* and *karonda* were noted on shoot length, root length, number of leaves and fresh weight of leaves of seedlings of annual crops. However, there was a significant increase in dry weight of seedlings of annual crops with the use of leaf extract of tree crops. Nonetheless, following the leaf extract of *karonda*, there was increase in germination of mustard (germination 93.3% as against 86.6% in control) and also of brinjal (germination 93.3% as against 88.3% in control). The leaf extract of *karonda* manifested positive influence on shoot length, root length, fresh weigh of leaves and also the dry weight of leaves of mustard and brinjal.

Tree fruits *viz*., *aonla*, *ber*, *karonda* grown under integration with annual crops (cluster bean, moth bean, mustard and brinjal) recorded significant increment in plant height including yield as compared to their sole crops. Marked increase in height of tree fruits under integrated cropping may be attributed to better agricultural practices carried out to grow annual crops along with applications of inputs like manures, fertilizers, insecticides, pesticides and irrigation etc. to annual crops. Addition of leaf biomass to the soil and their further decomposition as mulch *via* conserving moisture, favouring better source-sink relationship may be main attribute behind increased fruit yield under tree-crop integration. Positive interaction on plant growth parameters grown in association with annual crops have been reported by Lou and Aiyelogbe (9) in sweet orange, Singh (14), and Saroj *et al.* (12) in *ber*, and Awasthi (2) in *aonla*. However, in *aonla* lower fruit

**Table 4**. Allelopathic influence of aqueous leaf extracts of tree crops on seasonal crops Tree-crop farming system.

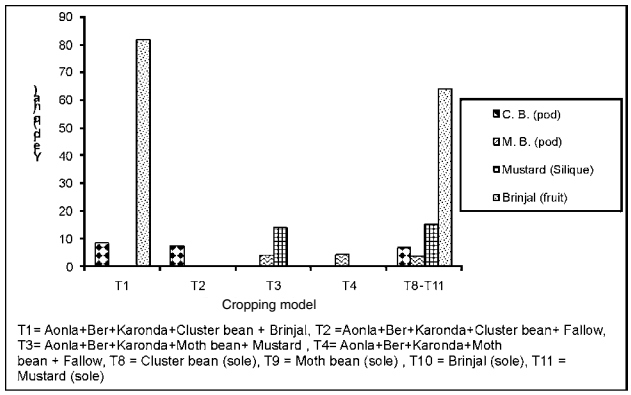
| Treatment | Germination per cent | Shoot length (cm) | Root length (cm) | Fresh weight of seedling (g) | Dry weight of seedlings (g) |
|---|---|---|---|---|---|
| $T_1$ *Aonla* (CB) | 89.90 (71.47) | 7.00 | 2.12 | 0.21 | 0.03 |
| $T_2$ *Aonla* (MB) | 93.30 (75.00) | 11.12 | 1.98 | 0.55 | 0.09 |
| $T_3$ *Aonla* (M) | 13.30 (21.39) | 3.10 | 1.20 | 0.49 | 0.08 |
| $T_4$ *Aonla* (B) | 83.30 (65.88) | 4.00 | 2.22 | 0.85 | 0.12 |
| $T_5$ *Ber* (CB) | 83.30 (65.88) | 6.80 | 1.98 | 0.23 | 0.03 |
| $T_6$ *Ber* (MB) | 93.30 (75.00) | 11.80 | 1.82 | 0.61 | 0.09 |
| $T_7$ *Ber* (M) | 23.30 (28.66) | 4.06 | 1.74 | 0.30 | 0.02 |
| $T_8$ *Ber* (B) | 83.30 (65.88) | 4.00 | 2.50 | 0.89 | 0.12 |
| $T_9$ *Karonda* (CB) | 83.30 (65.88) | 5.20 | 1.80 | 0.19 | 0.03 |
| $T_{10}$ *Karonda* (MB) | 83.30 (65.88) | 11.20 | 1.84 | 0.38 | 0.07 |
| $T_{11}$ K*aronda* (M) | 93.30 (75.00) | 9.40 | 2.87 | 0.81 | 0.14 |
| $T_{12}$ *Karonda* (B) | 93.30 (75.00) | 5.20 | 3.50 | 1.12 | 0.17 |
| $T_{13}$ Control (CB) | 100.00 (90.00) | 7.20 | 2.22 | 0.22 | 0.02 |
| $T_{14}$ Control (MB) | 95.00 (77.08) | 13.80 | 2.20 | 0.61 | 0.08 |
| $T_{15}$ Control (M) | 86.60 (68.53) | 8.41 | 2.30 | 0.73 | 0.06 |
| $T_{16}$ Control (B) | 88.30 (69.08) | 4.50 | 2.80 | 0.93 | 0.08 |
| $CD_{0.05}$ | 8.09 | 0.810 | 0.378 | 0.052 | 0.041 |

*Figures in parentheses are Arc Sine transformed values. **CB = Cluster bean, MB = Moth bean, M = Mustard, B = Brinjal.




T1 -Aonla+Ber+Karonda+Cluster bean + Brinjal; T2 -Aonla+Ber+Karonda+Cluster bean+ Fallow; T3 -Aonla+Ber+Karonda+Moth bean+ Mustard; T4 -Aonla+Ber+Karonda+Moth bean + Fallow; T5, T6, T7 - Sole tree fruits

**Fig. 1**. Yield of tree fruits under tree-crop farming system.




T1= Aonla+Ber+Karonda+Cluster bean + Brinjal, T2 =Aonla+Ber+Karonda+Cluster bean+ Fallow, T3= Aonla+Ber+Karonda+Moth bean+ Mustard , T4= Aonla+Ber+Karonda+Moth bean + Fallow, T8 = Cluster bean (sole), T9 = Moth bean (sole) , T10 = Brinjal (sole), T11 = Mustard (sole)

**Fig. 2.** Yield of different annual crops under tree-crop farming system.

yield was recorded due to the frost damage caused to plants. In integrated cropping models, annual crops grown between the interspaces during *kharif* and *rabi* seasons, showed better growth and yielded more than their respective sole crop except mustard where slightly lower plant height and yield were recorded. Ahuja (1) also observed better growth of annual crops under integrated cropping system in comparison to sole cropping under open field condition. This may be due to different absorption stratum of tree and annual crops avoiding competition. It may also be ascribed to improved soil fertility (Young, 20) and ameliorative influence of shade brought by tree in keeping metabolic activity on in plants especially in hot dry environment (Bunderson *et al*., 6). Earlier better growth and yield of annual crops have been reported in association with fruit trees like by Patil *et al*. (10). Considerably lower plant height and reduced yield in mustard grown during *rabi* season as compared to its sole crops may be due to better canopy growth of *ber* which must have restricted adequate penetration of solar radiation to pass through to the ground surface. The findings of present investigation are in consonance to results as reported by Saroj *et al.* (2002) in *ber*, and Awasthi *et al.* (2) in *aonla*.

Allelo-chemical studies revealed that the aqueous leaf extract of tree crops particularly those of *ber* and *aonla* delayed seed germination, reduced germination percentage and seedling vigour parameters like shoot length, root length, fresh weight and dry weight in all annual crops grown underneath tree. The inhibitory effect of leaf extract of tree crops on annual crops may be probably due to the presence of some water soluble allelo-chemicals in leaves of tree crops. Other compounds such as dammarane, saponin and zizynummin in *ber* while alkaloids, flavanoids, quinine, steroids and terpenoids in *aonla* might have affected the metabolic processes responsible for biosynthesis of GA, protein, $\alpha$-amylase, IAA and ATP etc. and thus may be responsible for inhibitory effect. The results are in conformity with those of Saroj *et al.* (13) and Awasthi *et al.* (3) where inhibitory effect of *ber* and *aonla* aqueous leaf extracts on the germination and seedling growth of mustard, wheat, gram, groundnut and cluster bean have been reported. Inhibitory effect of fruit crops like *Citrus aurantium* and *Syzygium cumini* on germination of annual crops have been reported by various workers; Hussain *et al.* (7), and Lal *et al.* (8) on germination of annual crops. Minimum inhibitory effect of *karonda* aqueous leaf extract on seed germination and seedling vigour parameters as compared to *ber* and *aonla* might be due to the stimulatory effect of allelo-chemicals present in aqueous leaf extract of *karonda*. The stimulatory effect of some perennials on growth and dry weight of annual crops have been reported by Narwal and Tauro (11), and Taherozzamen and Kushari (17).

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