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Impact of intercropping on growth and yield of brinjal [*solanum melongena,*(l)] under karanj (*pongamia pinnata*) based agroforestry system

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Abstract

The field experiment was laid out in randomize block design with eight treatments T1, 100% N and 100% P (120:70 kg/ha NP Fertilizer) + Azotobacter in T2. 75%N and 100% P (90:70kg /ha NP Fertilizer) + Azotobacter was applied in T3. 100N and100%P (120:70kg/ha NP Fertilizer) + PSB was applied in T4. 100%N and 75%P (120:52 kg/ha NP Fertilizer) +PSB was applied in T5. 100% N and 100%P (120:70 kg/ha NP Fertilizer) + Azotobacter + PSB was applied in T6. 75%N and75%P (90:52.5 kg/ha NP Fertilizer) + Azotobacter + PSB was applied in T7 and 8 recommended dose of fertilizer were applied and three replications. The results of the present study clearly indicated that the application of microbial and chemical fertilizers solely or combined application had a great influence at all the growth stages of the crop. Significant differences was observed in all parameters like, plant height, number of leaves and number of branches due to the combined application of microbial fertilizer and chemical fertilizer. 75% N + 75% P + Azotobacter + PSB. Performed highest growth and productivity of Brinjal variety Pant Rituraj intercropped under TBOS based Agroforestry system as compared with other treatments and as a sole crop with RDF. The results thus indicate that the application of microbial (Azotobacter + PSB) and chemical fertilizer is the best strategy which can be employed for the enhancement of growth and production efficiency since it had a positive impact under Pongamia pinnata *based Agroforestry system as compared with the sole crop of Brinjal Pant Rituraj variety without tree. It can be said that the Brinjal variety Pant Rituraj is suitable to be cultivated under Agroforestry system and higher returns as compared with sole crop.*

Key words: Integrated nutrient management, inter cropping systems, growth parameters, yield, brinjal

Introduction

Agroforestry is a collective name for land use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, *etc*.) are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence. In Agroforestry systems there are both ecological and economic interactions among the different components. Agroforestry, the integration of tree and crop or vegetable on the same area of land is a promising production system for maximizing, yield and maintaining friendly environment (Nair, 1990). Traditionally, agroforestry had its origins in developing nations where high population densities coupled with scarce land resources have required that concurrent food and wood production may be produced on the same land base with little compromise on principal of sustainability. Furthermore, tree- based inter-cropping systems can result in more diversified economies for both short- and long-term products and provide a market for both agronomic and forest crops. Inter-cropping systems can also play a vital role in sequestering carbon below ground and above-ground plant components, thereby addressing present and critical societal concerns about global climate change, with these potential benefits, successful tree based inter-cropping systems will minimize competitive interactions between non-woody (annual agricultural crop) and woody (tree) components while exploiting beneficial interactions between these components. Increasing our understanding of these interactions will provide a scientific basis for both improvement and adoption of tree- based inter-cropping systems.

In India, it is one of the most common, popular and principal vegetable crops grown throughout the country except higher altitudes. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. A number of cultivars are grown in India, consumer preference being dependent upon fruit color, size and shape. In our country, Brinjal cultivation shares the total production of about 12706 million tonnes per hectare. The global area has been estimated at 680 million hectares. (HSG 2015) The varieties of *Solanum melongena* L. display a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped; and from white, yellow, green through degrees of purple pigmentation to almost black. Most of the commercially important varieties have been selected from the long established types of the tropical India and China.

Materials and Methods

The present investigation ñImpact of Intercropping on Growth and Yield of Brinjal [*Solanum melongena,*(L)] under Karanj (*Pongamia pinnata*) Based Agroforestry Systemò was carried out during summer season of 2016-17 at the research farm of Department of Forestry, Indira Gandhi Krishi Vishwavidyalaya, Raipur. It lies at 21º.76ôN latitude and 81º.36ôE which longitude having an altitude of 295m. Above mean sea level. The climate of the study area is dry sub-humid tropical with an average rainfall of 1250 mm. Most of the rainfall (90%) is received during monsoon season from mid June to mid September. The average number of rainy days varies from 65 to 79. The mean monthly maximum temperature ranges from 42.5^{0}C in April to 44.6^{0}C in May and the minimum temperature below 08ºC in December.

The Experiment was started in the month of January 2017. The meteorological data ranges during the experimental period in maximum temperature 29^{0}C and minimum temp. 12.44^{0}C, relative humidity 84.6%, sun shine 7.6 hours and the rainfall 5.6 mm was recorded during transplanting time January 2017 and harvesting time maximum 37.8^{0}C temperature and minimum 26.05^{0}C temperature, relative humidity 75%, sun shine 5.5 hours recorded in the month of June. The soil of Raipur belongs to four different orders viz., Entisols, Vertisols, Inceptisols and Alfisols. The black clayey soil of experimental field belongs to the order Vertisols and it is locally known as Kanhar. This Kanhar soil are characterized by fine texture, sticky nature, angular blocky structure, low to medium Nitrogen, high Potassium and low to medium Phosphorus with low organic matter. The experiment was laid out in a randomized block design (RBD) with eight treatments viz. T1, 100% N and 100 % P (120:70 kg/ha NP Fertilizer) + Azotobacter in T2. 75%N and 100% P (90:70 kg /ha NP Fertilizer) + Azotobacter was applied in T3. 100N and100%P (120:70 kg/ha NP Fertilizer) + PSB was applied in T4. 100%N and 75%P (120:52 kg/ha NP Fertilizer) +PSB was applied in T5. 100% N and 100%P (120:70 kg/ha NP Fertilizer) + Azotobacter + PSB was applied in T6. 75%N and75%P (90:52.5 kg/ha NP Fertilizer) + Azotobacter + PSB was applied in T7 and 8 recommended dose of fertilizer were applied and three replications.

Results and discussion

The plant height of Brinjal under different treatments was recorded at 30, 60, 90, 120 and 150 days after transplanting and their results are presented in Table 1.The plant height of Brinjal was significantly influence with the increasing age of crop. The plant height ranges from (5.27 cm to 8.20 cm), (12.77 cm to 16.37 cm), (50.43 cm to 63.77 cm), (72.60 cm to 81.67 cm), (75.67 cm to 87.20 cm), at 30, 60, 90, 120 and 150 days respectively. The maximum average plant height of Brinjal was recorded in T7 (87.20 cm) followed by T5 (84.33 cm). The minimum average plant height was observed in T8 (75.67 cm) 100% as a sole crop. The study carried out by Latha *et al.,* (2014) also found similar result and recorded the maximum plant height (94 cm) in treatment 10 containing urea, super phosphate, Murate of potash, Azospirillum, Phosphobacteria and potassium mobilizer. Ramakrishnan and Selvakumar (2012) studied on effect of Bio-fertilizers application on growth and yield of tomato plants and conducted that the significantly high performance was recorded plant height as compared to all other characters Azotobacter with Azospirillum treated plants showed maximum growth of plant.

Number of leaves of Brinjal under different treatments was recorded at 30, 60, 90, 120 and 150 days after transplanting and their results are discussion in Table 2. The number of leaves of Brinjal was significantly influence with the increasing age of crop. The number of leaves ranged from (3.30 cm to 3.7 cm), (8.27 cm to 10.47 cm), (45.67 cm to 60.23 cm), (73.20 cm to 86.40 cm), and (80.90 cm to 91.27 cm), at 30, 60, 90, 120 and 150 days respectively. The Maximum number of leaves of Brinjal was recorded

in T4 treatment (91.27) followed by T3 treatment (85.60). The minimum number of leaves was observed in T8 treatment (80.90) as a sole crop. Kashyap *et al*. (2014) showed the maximum number of leaves per plant (103.8) recorded under the 75% RDF + neem cake and were significantly superior over other treatment but in our treatment it was (91.27) in T4 treatment this might be because of varietal difference (Pant Rituraj) and may be due to shad condition.

Table 1: Effect of Bio-fertilizer on plant height of Brinjal intercropped under Karanj based Agroforestry System

	Plant height (cm)				
Treat.	30DAT	60DAT	90DAT	120DAT	150DAT
T1	7.85	14.83	59.27	79.30	83.50
T2	7.13	13.67	60.60	79.47	81.97
T3	6.63	14.70	59.40	79.43	82.47
T4	7.00	15.17	58.53	79.40	83.07
T5	6.77	14.67	60.63	82.00	84.33
T6	7.03	15.33	60.67	80.37	83.80
T7	8.20	16.37	63.77	81.67	87.20
T8	5.27	12.77	50.43	72.60	75.67
F- test	S	S	S	S	S
SEm±	0.35	0.64	1.68	1.49	1.60
CD at 5%	1.06	1.94	5.08	4.51	4.86

Table 2: Effect of Bio-fertilizer on number of leaves of Brinjal intercropped under Karanj based Agroforestry System

	Number of leaves				
Treat.	30DAT	60DAT	90DAT	120DAT	150DAT
T1	3.53	9.93	56.20	81.90	83.83
T2	3.67	8.53	58.53	81.33	82.40
T3	3.40	9.73	57.33	82.00	85.60
T4	3.77	10.47	60.23	86.40	91.27
T5	3.67	8.80	58.43	81.37	83.93
T6	3.50	9.17	59.43	84.17	84.93
T7	3.70	8.77	58.80	83.10	84.70
T8	3.30	8.27	45.67	73.20	80.90
F- test	S	S	S	S	S
SEm ±	0.09	0.44	1.76	1.69	1.74
CD at 5%	0.27	1.32	5.33	5.12	5.28

Number of branches of Brinjal under different treatments was recorded at 60, 90, 120 and 150 days after transplanting and their results are presented in Table 3. The number of branches ranges from (2.67 to 3.60), (5.00 to 6.50), (5.50 to 7.30), (6.03 to 9.17), at 60, 90, 120 and 150 days respectively. The Maximum average number of branches of Brinjal was recorded in T7 treatment (9.17) followed by T6 treatment (7.23). The minimum number of branches was observed in T8 treatment (6.03) as a sole crop. Similarly maximum number of branches per plant (9.22) was observed under RDF + Neem cake at (25% + 75%) which was significantly superior over all other treatments and as well as control that showed minimum number of branches per plant (1.33) according to Kashyap *et al.* (2014) in the present finding maximum number of branches were found under T7 treatment (9.17). This might be because of Bio-fertilizer application. Bio-fertilizer, along with N and P application is the best combination for the same result enhance of number of branches in Brinjal.

Table 3: Effect of Bio-fertilizer on number of branches of Brinjal intercropped under Karanj based Agroforestry System.

	Number of branches			
Treat.	60DAT	90DAT	120DAT	150DAT
T1	2.67	5.80	6.60	6.67
T2	2.67	6.13	6.73	7.00
T3	2.77	6.40	6.67	6.93
T4	2.77	5.87	6.83	7.07
T5	2.87	5.93	6.73	6.87
T6	2.90	6.37	6.93	7.23
T7	3.60	6.50	7.30	9.17
T8	2.67	5.00	5.50	6.03
F- test	S	S	S	S
SEm±	0.17	0.27	0.29	0.34
CD at 5%	0.50	0.83	0.87	1.04

Number of flower of Brinjal under different treatments was counted in each plot and the results are presented in Table 4. Maximum number of flowers was observed under in treatment T7 (25.47) followed by T6 (23.60) and the minimum number of flower was observed under open field with RDF T8 (15.63) treatment. Aminifard *et al.* (2004) also found that nitrogen application decreased the days of ûrst ûowering and treated plants ûowered early than control. Numbers of fruits of Brinjal under different treatments were counted in each plot and their results are presented in Table 4. Maximum number of fruits were observed in treatment T7 (24.80) followed by T5 (28.76) and the minimum number of fruits were observed an open field with RDF T8 (13.35) treatment. Saiyad (2014) reported that in Brinjal the combination of Bio-fertilizer with inorganic fertilizer the total number of fruit per plant^{-1} increased. Ramakrishnan

and selvakumar (2012) found that significantly high performance in number of fruit per plant.

Table 4: Effect of Bio-fertilizer on number of fruit of Brinjal itercropped under karanj based Agroforestry System

Treatments	Number of flower	Number of fruit
T1	19.3	17.27
T2	19.33	19.57
T3	17.32	18.90
T4	18.5	21.43
T5	17.63	21.57
T6	23.61	20.30
T7	25.47	24.80
T8	15.63	13.35
F- test	S	S
SEm±	1.69	1.09
CD at 5%	4.65	3.30

After harvesting of fruit length of Brinjal under different treatments was measured with the help of venire callipers and their results are presented in Table 5. Maximum average fruit length was observed under treatment T7 (6.83cm), followed by T6 (5.29cm), and the minimum average fruit length was recorded an open field with RDF as a sole crop treatment T8 (4.96 cm).

Fruit breadth was measured with the help of digital calliper and their results are presented in Table 5. Maximum fruit breadth of Brinjal was observed in T7 in (5.61cm), followed by T5 (5.21cm) and the minimum fruit breadth of was observed in RDF T8 at (4.12 cm). Ullah *et al*. (2008) also found similar result fruit diameter (4.3cm) and five treatment consist of organic and combined source of nutrient, of which the combined treatment (60% organic + 40 inorganic) showed the best performance.

Table 5: Effect of Bio-fertilizer on fruit length and breadth of Brinjal intercropped under Karanj based Agroforestry System

Treatments	Fruit length (cm)	Fruit breadth(cm)
T1	5.18	4.61
T2	5.01	4.57
T3	5.15	4.55
T4	5.29	4.55
T5	5.26	4.79
T6	5.62	4.85
T7	6.07	5.34
T8	4.79	4.07
F- test	S	S
SEm±	0.17	0.21
CD at 5%	0.52	0.65

Date of first flowering days taken from crop of Brinjal under different treatments was recorded at the time of first Flowering and their results are presented in Table 6. In treatment T6 and T7 took the early flowering days (51.33 days) followed by T4 (58.33). However, treatment T8 took longer time (65.667days) as a sole crop. The early flowering may be because of good nutrient availability, moisture and partial light may be the reason T7 showed early flowering compared with the sole crop in T8 treatment. Maske *et al.* (2015) reported that the Brinjal crop attain early flower initiation (51.47 day), and minimum number of day required for 50% flowering (58.20 day), were recorded in treatment T1 (without tree with RDF) in Parbhani.

Table 6: Effect of Bio-fertilizer on days of first flowering and fruiting, days of last flowering and fruiting of Brinjal intercropped under karanj based Agroforestry System

Treatments	First flowering days	First fruiting days	Last flowering days	Last fruiting days
T1	59.67	69.00	128.00	130.00
T2	60.00	71.00	127.33	128.33
T3	61.67	67.33	124.33	129.67
T4	58.33	64.33	125.00	129.33
T5	62.67	67.00	125.67	128.33
T6	51.33	57.33	122.00	124.33
T7	51.33	57.00	121.67	122.33
T8	65.67	76.00	129.33	131.00
SEm±	2.14	2.38	0.83	1.73
CDat 5%	13.94	7.21	2.51	5.24

Date of last flowering recorded the crop of brinjal under different treatments and their results are presented in Table 6. In case of T7 treatment took the last flowering (121days) for last flowering, respectively, followed by T8 (128 days for last flowering). Date of first fruit day taken from crop of Brinjal under different treatments was recorded at the time of first fruit and their results are presented in Table 6. Date of first Fruit of plants showed statistically significant (PÂ0.05) by Bio-fertilizer in treatment T7 took the first fruit days (57 days) followed by T6 (57.33days). However, treatment T8 took longer time (76days) as a sole crop. Date of last fruiting recorded the crop of Brinjal under different treatments and their results are presented in Table 6. In case of T7 treatment took the last fruiting (122.33 days) for last fruiting , respectively, followed by T6 (124.33) days for last fruiting). The last fruiting

in the plant is related with the maturity of plant and moisture nutrient aviability may be the reason. The T8 treatment as sole crop the last fruiting was in (131.00) days more as compare with T7 and T6.

Maximum and minimum fruit weight, of Brinjal

Maximum fruit weight of Brinjal was recorded under different treatments and their results are presented in Table 7. The maximum fruit weight of Brinjal was observed under T7 treatment (85.50g) followed by T7 (81.80g) However the minimum fruit weight of was observed in T8 without tree with RDF (71.93g).

Table 7: Effect of Bio-fertilizer on fruit weight maximum/ fruit weight minimum of Brinjal intercropped under karanj based Agroforestry system

	Fruit Weight (gm)				
Treat.	90 DAT	105 DAT	120 DAT	135DAT	150 DAT
T1	75.67	73.33	75.53	75.07	78.50
T2	70.67	75.73	76.93	74.20	80.73
T3	67.33	79.27	76.93	74.80	78.47
T4	75.23	82.07	75.33	73.07	78.93
T5	76.93	80.73	72.73	76.67	78.00
T6	73.40	82.60	77.27	80.27	81.80
T7	86.30	88.20	86.00	83.73	85.50
T8	58.20	67.13	67.03	69.40	71.93
F- Test	S	S	S	S	S
SEm±	4.60	2.29	3.16	2.29	1.97
CD at5%	13.94	6.95	9.58	6.93	5.99

Fruit yield plant^{-1} and fruit yield quintal ha^{-1} of brinjal

After harvesting fruit yield plant^{-1} of Brinjal under different treatments was recorded the each plot and their results are presented in Table 8. Maximum fruit yield plant^{-1} of Brinjal was observed under in treatment T7 (2.81 kg) followed by T6 (2.43 kg) and the minimum fruit yield plant^{-1} was observed an open field with RDF as a sole crop T8 (1.87 kg) treatment. Hadidi *et al.,* (2011) intercropped with okra, significantly highest yield (16.66 ton ha^{-1}). After harvesting fruit productivity kg ha^{-1} of Brinjal under different treatments was recorded the each plot and their results are presented in table 8. Maximum fruit productivity quintal ha $^{-1}$ of Brinjal was recorded under in treatment T7 (642.54 qn) followed by T6 (554.36 qn) and the minimum fruit productivity was observed an open field with RDF T8 (427.60 qn) treatment. The study carried out by Chand (2007) showed that fruit yield quintal/ ha was significantly increased in tomato crop treated with Azotobactor+100% of recommended N+ recommended P_2O_5 & K_2O kg acre^{-1}).

Table 8 Effect of Bio-fertilizer on fruit yield kg plant^{-1} and fruit yield qn ha^{-1} of Brinjal intercropped under karanj based Agroforestry System

Treatments	Fruit yield kg plant^{-1}	Fruit yield q ha^{-1}
T1	2.19	501.50
T2	2.26	521.72
T3	2.34	534.67
T4	2.17	489.23
T5	2.20	502.10
T6	2.43	554.36
T7	2.81	642.54
T8	1.87	427.60
F- test	S	S
SEm±	0.13	4.73
CD (at 5%)	0.38	14.34

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