

Root yield and yield attributes of *Aristolochia indica* L. (Piperales: Aristolochiaceae) as effected by different spacing and fertilizer treatments in the North-East India

Rumi Kotoky*, Anulekha Rabha and P. B. Kanjilal

Medicinal, Aromatic and Economic Plants Division. North-East Institute of Science and Technology, Jorhat-785006. India. *Email: kotoky15@yahoo.co.in.

Abstract. *Aristolochia indica* L. belonging to the Family Aristolochiaceae is used in Indigenous System of Medicine. The leaves are used in the treatment of cholera, fever and bowel troubles and roots are acrid digestive and also useful in ulcers, leprosy, skin diseases and all types of poisonous bites. A field experiment was conducted in the experimental farm of North-East Institute of Science and Technology, Jorhat, India to evaluate the root yield and yield attributing parameter of plant *Aristolochia indica*, with application of different spacing and different doses of fertilizer trial. The results revealed that the plant responded to different spacing treatments significantly. Among the different spacings maximum plant height (460.25 cm), leaf number per plant (296.53) and leaf area per plant (115.00 cm²) has been observed in the spacing 90 cm x 45 cm whereas maximum dry root yield (2.09 t/ha) is recorded at the spacing of 90 cm x 90 cm. Linear increase in dry root yield has been found with the increase of spacing. In the first year dry root yield of the plant showed positive correlation with all the parameters except the primary branch number. But in the second year the same showed significant positive correlation with other yield attributing components. Application of different doses of fertilizers influenced the growth and yield in the crop. Maximum plant height (359.40 cm), leaf number per plant (450.20) and leaf area per plant (170.34 cm²) were recorded with 100:60:100 kg/ha NPK which is significantly superior to other doses. Use of 100 kg N/ha produced maximum dry root yield ranging from 2.18 t/ha to 2.31 t/ha in combination with both the doses of P and K. Root yield of the second year showed significant positive correlation with rest of the yield components. The results indicated that harvesting the crop in second year will be beneficial for getting higher root biomass.

Keywords: *Aristolochia indica*, Medicinal properties, Spacing trials, Fertilizer trials, Root yield.

Introduction

Aristolochia indica L. (Piperales: Aristolochiaceae) is one of the 300 species belonging to the family Aristolochiaceae is a perennial shrubby glabrous twiner with a long rootstock. It is extensively found throughout the low elevations and plains of

India, Nepal and lower Bengal to Chittagong in Bangladesh and Coromondal coast (Anonymous, 1948, Chopra et al., 1956). The plant has got great medicinal importance and from root to leaf each and every part of the plant is used in indigenous system of medicine (Anonymous, 1943). Leaves are used to treat cholera, fever and

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bowel troubles (Chatterjee and Pakrashi, 1991). Roots are bitter, acrid digestive and also useful in ulcers, leprosy and antidiarrhoeal activity (Chopra et al., 1956; Benarba and Meddah, 2013; Dharmalingan et al., 2014). The essential oil composition of the root and aerial parts of this plant has been studied by Krishna Rao et al. (1935), Rao and Mulhara (1955), Jirovetz et al. (2000) and Kanjilal et al. (2009). The importance of *Aristolochia indica* L. for its traditional medicinal practices has attracted many of the workers in that field with reference to explore its propagative potentialities (Bliss et al., 2009; Bliss et al., 2013). The review of *Aristolochia indica* Dey and De (2011), has given extensive studies on the plant species. However, not much agronomical studies have been conducted to explore the potential of this plant in a sustainable manner. The demand for medicinal plants is ever increasing as people are fascinated more towards the herbal products.

Keeping this in view, the present investigation has been undertaken to understand the growth potentialities and yield attributes by employing different doses of fertilizer and spacing treatment.

Materials and methods

The field trial was conducted at the Experimental Farm of North-East Institute of Science and Technology, Jorhat, India which lies between Longitude 94° 09' 31" E and Latitude 26° 44' 19" N during 2011-2013. The area enjoys a moderate climate with mean annual rainfall

of 2195.31 mm and temperature varied from 19.72 °C ± 3.40 °C (minimum) to 28.90° ± 3.40 °C (maximum).

The crop was raised in sandy loam soil having pH 5.5, organic matter 0.86%, available nitrogen, phosphorus and potassium 0.075, 0.0006 and 0.0034%, respectively. The experiment was laid out in a randomized block design with three replications having six plant spacing treatments 45 cm x 45 cm (S1), 45cm x 60 cm(S2), 90cm x 45 cm (S3), 60 cm x 60 cm (S4), 60 cm x 90 cm (S5) and 90 cm x 90 cm (S6) and 12 NPK combinations of 50:60:50 (F1), 50:60:100 (F2), 50:120:50 (F3), 50:120:100 (F4), 100:60:50 (F5), 100:60:100 (F6), 100:120:50 (F7), 100:120:100 (F8), 150:60:50 (F9), 150:60:100 (F10), 150:120:50 (F11) and 150:120:100 (F12) kg/ha, respectively, along with the control. Matured seed of *A. indica* are sown in raised seed bed in June and the seedlings are planted in the experimental field in the month of October.

Growth parameters like plant height, primary branch number, secondary branch number and leaf number are recorded in 3 month intervals. Root biomass and root yield data collected in 360 days interval. Statistical analysis has been performed using the software Systate 12.

Results and discussions

The data pertaining to effect of spacing and fertilizer on yield attributed parameters and yield of *Aristolochia indica* is presented in Table 1 and Table 2.

Table 1. Yield data of different spacing trial of *Aristolochia indica* L.

SI No.	Parameters→ Treatments↓	Plant height (cm)		Primary branch no./ Plant		Secondary branch no./ Plant		Leaf no./ Plant		Leaf area/ Plant (cm ²)		Root biomass/Plant (gm)		Dry root yield (calculated) (t/ha)	
		1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
1	45 cm X 45 cm	200.56	358.89	4.53	7.14	5.65	10.6	201.03	233.73	78.00	91.00	5.65	44.40	0.99	1.13
2	45 cm X 60 cm	224.83	353.97	3.53	8.93	10.60	19.04	230.20	275.55	89.00	107.00	16.37	47.00	1.01	1.41
3	90 cm X 45 cm	260.50	460.25	6.26	6.67	15.73	17.07	235.18	296.53	91.00	115.00	15.73	51.20	1.19	1.60
4	60 cm X 60 cm	233.12	417.02	5.33	10.26	14.5	15.00	256.70	284.78	99.00	111.00	14.50	52.26	1.07	1.45
5	60 cm X 90 cm	259.50	453.15	4.86	9.73	14.73	20.67	242.30	293.42	94.00	114.00	20.67	63.30	1.32	1.99
6	90 cm X 90 cm	236.80	359.31	3.60	7.33	11.33	18.40	194.20	245.70	75.00	95.00	18.40	63.90	1.49	2.09
SEM±		0.26	19.59	0.37	0.21	0.31	0.66	0.34	1.91	0.20	0.66	1.68	1.76	0.04	0.05
CD (5%)		0.57	42.70	0.81	0.46	0.67	1.44	0.74	4.16	0.43	1.44	3.66	3.84	0.1	0.11

Table 2. Yield data of different fertilizer treatments of *Aristolochia indica* L.

SI No.	Parameters→ Treatments↓	Plant height (cm)		Primary branch no./ Plant		Secondary branch no./ Plant		Leaf no./ Plant		Leaf area/ Plant (cm ²)		Root biomass/Plant (gm)		Dry root yield (calculated) (t/ha)	
		1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
1	F0	134.03	204.00	7.20	10.60	12.36	13.40	150.50	271.40	58.32	105.38	34.50	54.30	0.77	1.21
2	F1	231.40	341.70	9.80	13.40	15.93	16.30	293.20	395.20	113.85	153.45	58.40	76.60	0.85	1.70
3	F2	165.40	272.40	10.90	15.60	16.86	16.40	251.50	220.60	97.57	85.65	41.60	76.50	0.89	1.69
4	F3	177.70	290.60	10.20	14.20	15.53	17.20	276.40	302.40	107.32	117.41	50.00	82.60	1.11	1.83
5	F4	187.50	300.40	12.30	16.40	17.10	20.20	340.00	375.70	132.02	141.28	54.50	86.70	0.92	1.92
6	F5	212.50	325.60	11.70	15.90	14.80	19.60	349.60	378.60	135.75	143.35	56.90	101.00	1.30	2.24
7	F6	239.20	359.40	8.90	14.20	15.40	21.30	415.20	450.20	161.22	170.34	62.40	101.10	1.56	2.31
8	F7	198.60	309.40	8.30	15.60	13.76	20.40	410.34	426.50	159.39	163.21	52.10	102.60	1.35	2.28
9	F8	162.50	276.50	9.80	13.90	14.20	17.60	275.00	330.50	106.76	121.14	37.40	98.40	1.39	2.18
10	F9	216.0	330.40	8.90	12.60	16.50	19.40	347.30	432.00	134.85	156.58	60.70	92.60	1.29	2.10
11	F10	169.40	299.70	9.10	13.00	13.70	18.70	349.20	311.60	135.59	126.12	59.00	97.20	1.31	2.16
12	F11	208.60	316.40	9.70	14.20	16.70	19.40	307.30	373.40	119.32	136.06	56.20	91.40	1.25	2.03
13	F12	161.90	300.00	10.70	15.90	14.60	21.60	275.30	370.60	106.89	131.62	38.20	86.40	1.21	1.99
	SEM±	0.58	2.57	0.51	0.80	0.56	0.72	1.05	2.17	0.42	8.60	2.10	2.29	0.04	0.03
	CD (5%)	1.19	5.27	1.04	1.64	1.15	1.50	2.15	4.45	0.86	17.63	4.30	4.70	0.08	0.06

Effect of Spacing

Results revealed that the yield components and yield were significantly affected by planting geometry. Maximum plant height 460.25 cm (Figure 1), leaf area per plant 115.00 cm² (Figure 2), leaf number per plant 296.53 (Figure 3) and has been observed in the spacing 90 cm x 45 cm in the second year. But primary and secondary branch number per plant has failed to show a definite trend with different spacing treatments. On the

other hand the root biomass (Figure 4) and root yield (Figure 5) has shown an increasing trend with wider spacing and decline in root yield with closer spacing. Highest root biomass per plant in the first year is recorded in the spacing 60 cm x 90 cm with 20.67 g whereas the same in 90 cm x 90 cm with 63.90 g in the second year. Dry root yield also maximum in 90 cm x 90 cm spacing. All the characters were shown in different figures, effect of spacing treatment in both the year.

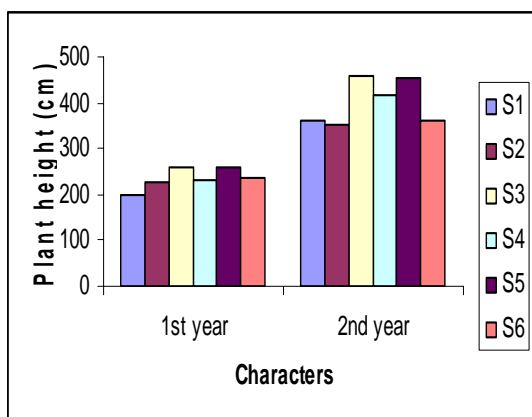


Figure 1. Plant height.

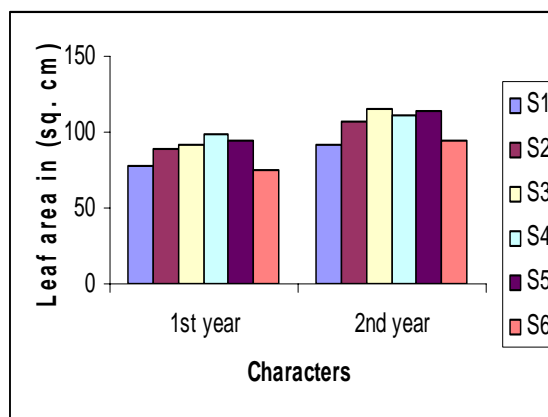


Figure 2. Leaf area per plant.

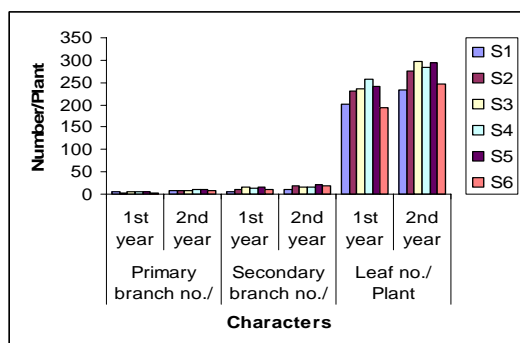


Figure 3. Leaf number per plant.

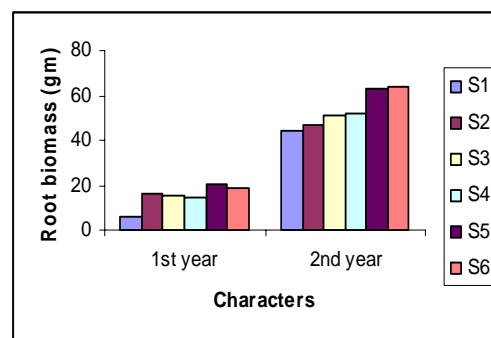


Figure 4. Primary and secondary branch no and root biomass.

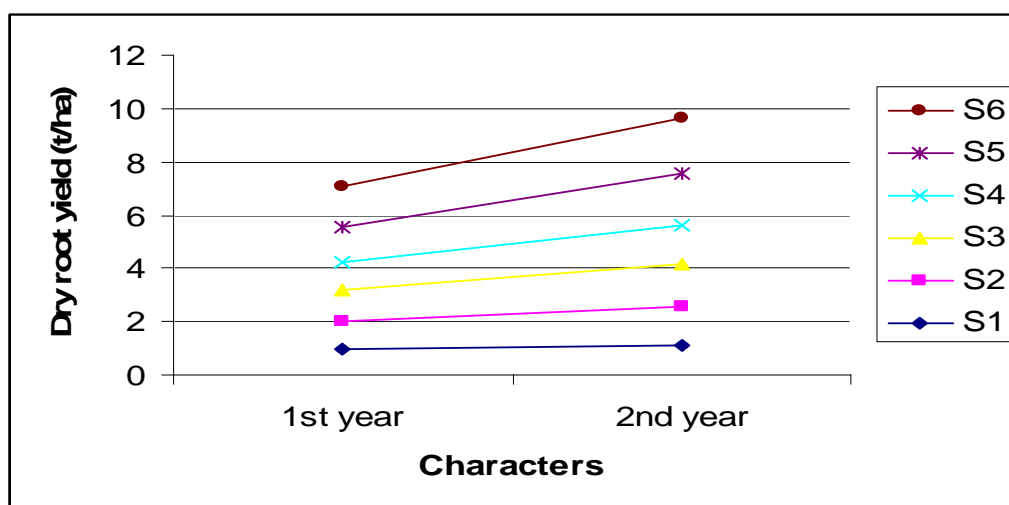


Figure 5. Dry root yield (t/ha).

Effect of fertilizers

The plant responded significantly with different doses of fertilizers in both the years. It showed maximum plant height (Figure 6), maximum leaf area per plant (Figure 7), leaf number per plant (Figure 8) highest root biomass (Figure 9) and root yield (Figure 10) with a constant dose of nitrogen i.e., 100 kg/ha with different doses of phosphate and potassium i.e., 60 kg/ha and 120 kg/ha and 50 kg/ha and 100 kg/ha, respectively. The maximum primary and secondary branch numbers in both the years has been recorded with the treatment 50:120:100 (F4) and 150:120:100 kg/ha of NPK. The availability of nutrition in adequate quantity improves the root yield of *A. indica*. Effect of fertilizer treatment on different characters were shown in different figures in both the year.

Correlations

In the first year all the yield attributing parameters along with the root yield showed positive correlation except the primary branch number in the spacing trial (Figure 11). While in the second year all the factors showed strong positive correlations with each other. The root yield showed strong positive correlation with all the yield attributing factors both in the second year and first year except the primary and secondary branch number in the first year of the fertilizer trial (Figure 12).

Combined 1st and 2nd year correlation matrix

In the first year the dry root yield showed positive correlation with all other growth factors except the primary branch

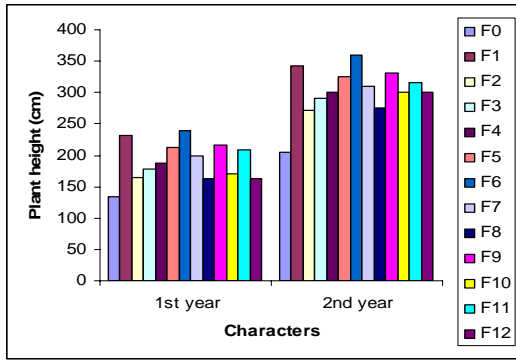


Figure 6. Plant height.

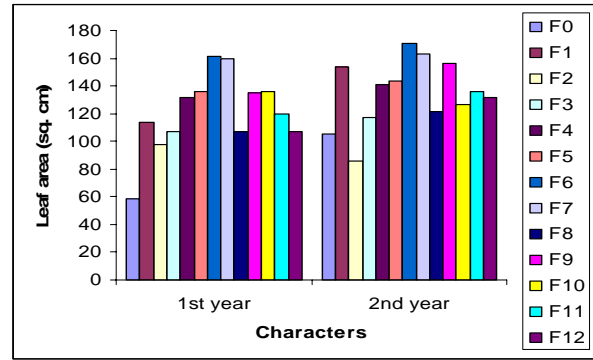


Figure 7. Leaf area per plant.

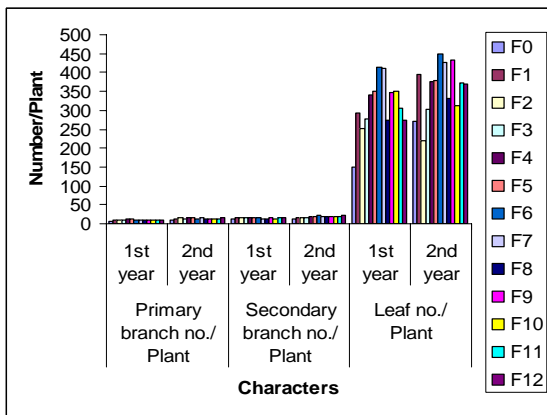


Figure 8. Leaf number per plant.

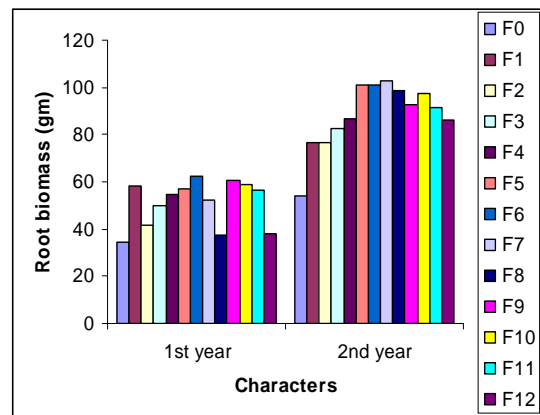


Figure 9. Primary and secondary branch no and root biomass.

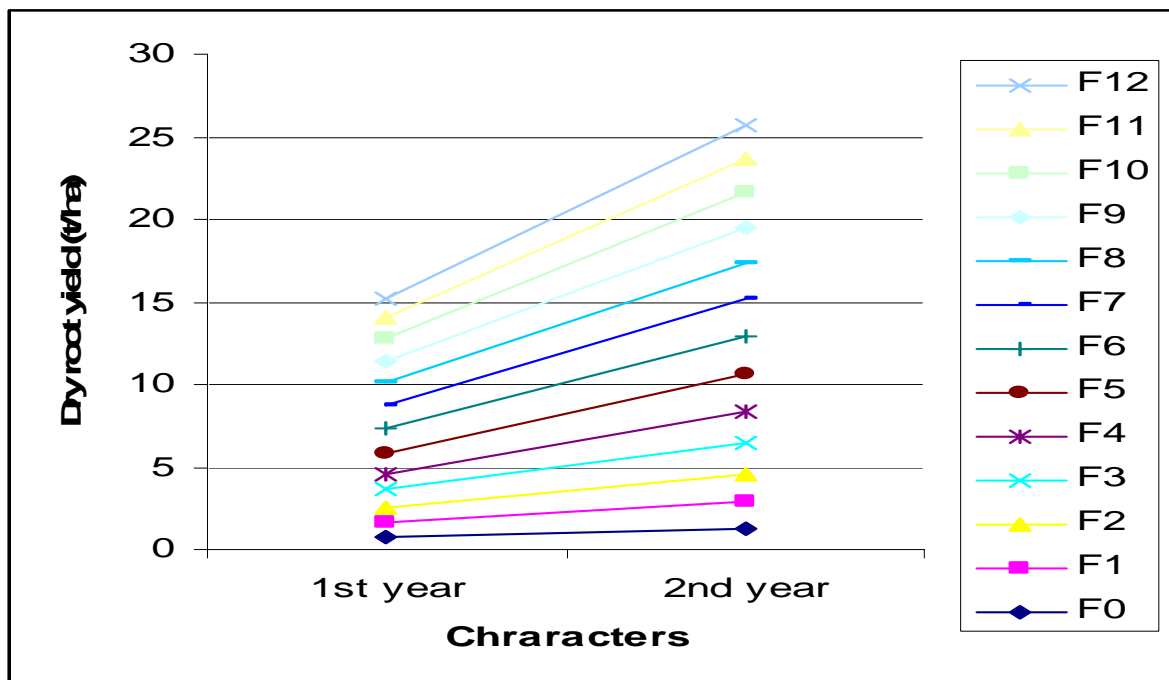


Figure 10. Dry root yield (t/ha).

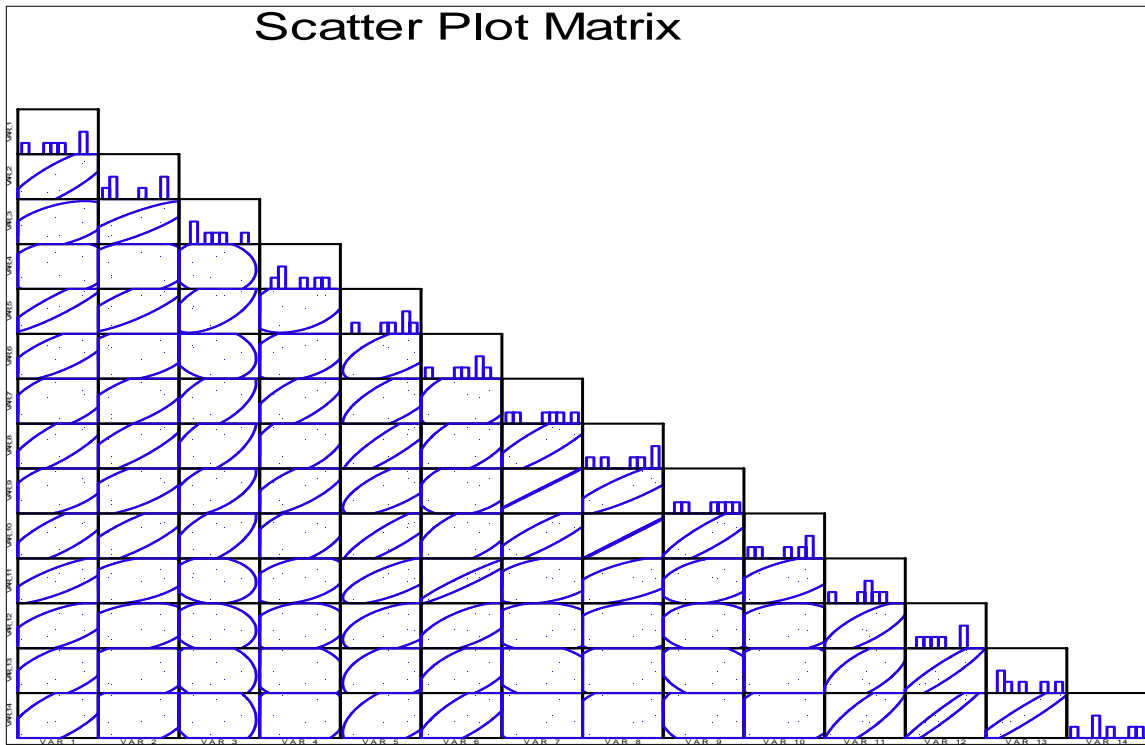


Figure 11. Correlation of spacing trial.

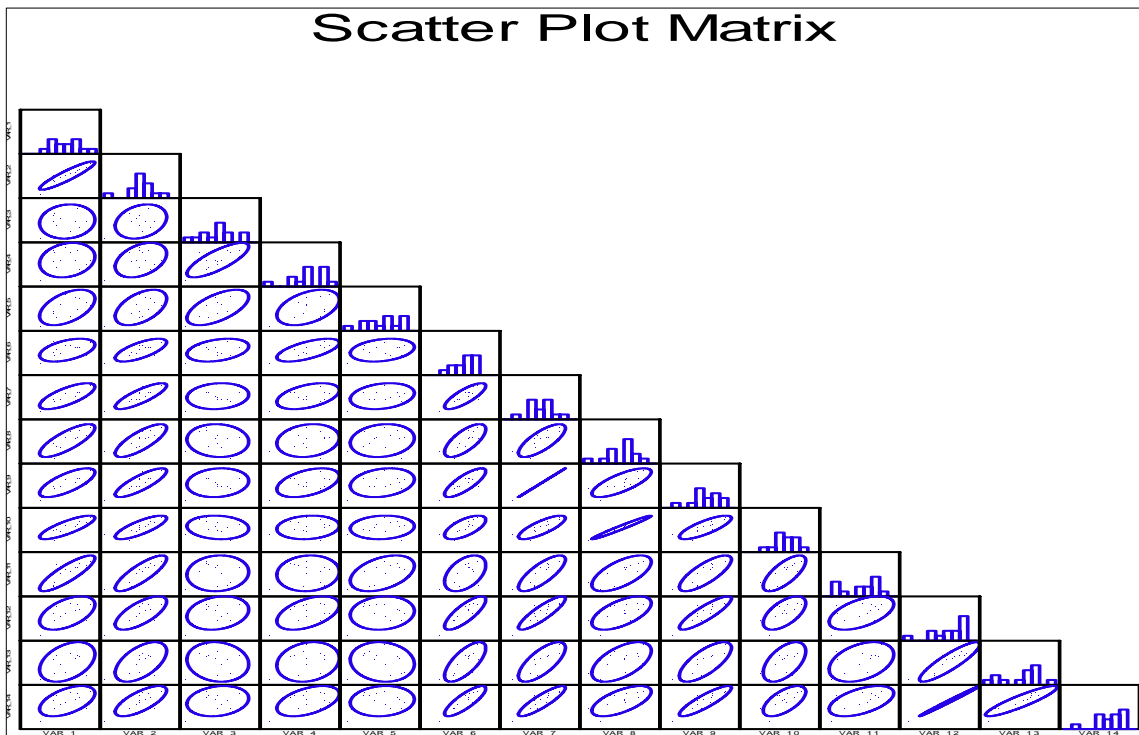


Figure 12. Correlation of fertilizer trial.

number but in the second year it showed strong positive correlation with those in the spacing trial (Table 3 and Table 4).

The correlation coefficient is a good indicator to decide the criteria for selection (Dakshina et al., 2008). In our

Table 3. Correlation matrix of first and second year of spacing treatments.

SI No.	Parameters→ Treatments↓	Plant height (cm)		Primary branch no./ Plant		Secondary branch no./ Plant		Leaf no./ Plant		Leaf area/ Plant (cm ²)		Root biomass/Plant (gm)		Dry root yield (calculated) (t/ha)	
		1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
1	45 cm X 45 cm	200.56	358.89	4.53	7.14	5.65	10.6	201.03	233.73	78.00	91.00	5.65	44.40	0.99	1.13
2	45 cm X 60 cm	224.83	353.97	3.53	8.93	10.60	19.04	230.20	275.55	89.00	107.00	16.37	47.00	1.01	1.41
3	90 cm X 45 cm	260.50	460.25	6.26	6.67	15.73	17.07	235.18	296.53	91.00	115.00	15.73	51.20	1.19	1.60
4	60 cm X 60 cm	233.12	417.02	5.33	10.26	14.5	15.00	256.70	284.78	99.00	111.00	14.50	52.26	1.07	1.45
5	60 cm X 90 cm	259.50	453.15	4.86	9.73	14.73	20.67	242.30	293.42	94.00	114.00	20.67	63.30	1.32	1.99
6	90 cm X 90 cm	236.80	359.31	3.60	7.33	11.33	18.40	194.20	245.70	75.00	95.00	18.40	63.90	1.49	2.09
SEM±		0.26	19.59	0.37	0.21	0.31	0.66	0.34	1.91	0.20	0.66	1.68	1.76	0.04	0.05
CD (5%)		0.57	42.70	0.81	0.46	0.67	1.44	0.74	4.16	0.43	1.44	3.66	3.84	0.1	0.11

Characters		Plant height (cm)		Primary branch no./ Plant		Secondary branch no./ Plant		Leaf no./ Plant		Leaf area/ Plant (cm ²)		Root biomass/ Plant (gm)		Dry root yield (calculated) (t/ha)	
		1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.
Plant height (cm)	1 st yr.	1.000													
	2 nd yr.	0.828	1.000												
Primary branch no./ Plant	1 st yr.	0.495	0.848	1.000											
	2 nd yr.	0.126	0.187	-0.070	1.000										
Secondary branch no./ Plant	1 st yr.	0.191	0.826	0.576	0.350	1.000									
	2 nd yr.	0.739	0.314	-0.183	0.321	0.628	1.000								
Leaf no./ Plant	1 st yr.	0.487	0.679	0.557	0.720	0.724	0.284	1.000							
	2 nd yr.	0.805	0.826	0.595	0.451	0.897	0.577	0.878	1.000						
Leaf area/ Plant (cm ²)	1 st yr.	0.490	0.686	0.561	0.718	0.721	0.285	1.000	0.881	1.000					
	2 nd yr.	0.791	0.826	0.601	0.466	0.890	0.560	0.891	1.000	0.893	1.000				
Root biomass/ Plant (gm)	1 st yr.	0.575	0.190	-0.138	-0.149	0.375	0.578	-0.286	0.014	-0.288	-0.008	1.000			
	2 nd yr.	0.697	0.290	-0.140	0.077	0.525	0.769	-0.066	0.228	-0.067	0.208	0.958	1.000		
Dry root yield (calculated) (t/ha)	1 st yr.	0.809	0.407	-0.074	0.369	0.743	0.966	0.342	0.604	0.339	0.588	0.681	0.853	1.000	
	2 nd yr.	0.629	0.302	-0.118	0.190	0.487	0.667	-0.031	0.178	-0.032	0.163	0.937	0.973	0.783	1.000

Table 4. Correlation matrix of first and second year of fertilizer trials.

Characters		Plant height (cm)		Primary branch no./ Plant		Secondary branch no./ Plant		Leaf no./ Plant		Leaf area/ Plant (cm ²)		Root biomass/ Plant (gm)		Dry root yield (calculated) (t/ha)	
		1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.	1 st yr.	2 nd yr.
Plant height (cm)	1 st yr.	1.000													
	2 nd yr.	0.922	1.000												
Primary branch no./ Plant	1 st yr.	0.110	0.263	1.000											
	2 nd yr.	0.201	0.381	0.781	1.000										
Secondary branch no./ Plant	1 st yr.	0.493	0.498	0.604	0.440	1.000									
	2 nd yr.	0.475	0.693	0.340	0.642	0.271	1.000								
Leaf no./ Plant	1 st yr.	0.725	0.821	0.128	0.452	0.240	0.797	1.000							
	2 nd yr.	0.785	0.779	-0.067	0.173	0.156	0.698	0.754	1.000						
Leaf area/ Plant (cm ²)	1 st yr.	0.725	0.821	0.128	0.452	0.240	0.798	1.000	0.754	1.000					
	2 nd yr.	0.812	0.790	-0.108	0.138	0.106	0.647	0.794	0.983	0.795	1.000				
Root biomass/ Plant (gm)	1 st yr.	0.853	0.827	0.086	0.089	0.424	0.456	0.773	0.643	0.773	0.714	1.000			
	2 nd yr.	0.510	0.689	0.213	0.486	0.121	0.792	0.870	0.597	0.870	0.593	0.531	1.000		
Dry root yield (calculated) (t/ha)	1 st yr.	0.395	0.549	-0.117	0.183	-0.112	0.700	0.713	0.564	0.713	0.541	0.379	0.885	1.000	
	2 nd yr.	0.521	0.708	0.193	0.476	0.117	0.826	0.875	0.630	0.875	0.620	0.529	0.996	0.906	1.000

investigation it was observed that in spacing trial root biomass per plant (gm) were positively correlated with secondary branch number per plant followed by plant height and negatively correlated with primary branch number per plant and leaf area per plant (cm). But Dry root yield (t/ha) were positively correlated secondary branch/plant, plant height followed by root biomass/plant.

In fertilizer treatment, the root biomass /plant(gm) were positively correlated with leaf area/plant(cm) followed by leaf number/plant and plant height. Dry root yield (t/ha) were positively correlated with root biomass/plant followed by leaf area and leaf number per plant and plant height. Dry root yield correlation with root biomass. Therefore, these relationship indicate the characters such as dry root yield and root biomass, plant height, leaf no and leaf area per plant should be taken in to consideration during selection both the spacing and fertilizer treatment.

Conclusion

Results revealed that the yield components and yield were significantly affected by planting geometry. The root biomass and root yield has shown an increasing trend with wider spacing and decline in root yield with closer spacing. Therefore the spacing 90cm c 90 cm (S6) can be considered as idle spacing in *Aristolochia indica* plantation to get maximum root yield (2.09 t/ha, dry weight basis).

The availability of nutrition in adequate quantity improves the root yield of *A. indica*. In the treatment NPK: 100:60:100 kg/ha (F6) highest root yield (2.31 t/ha in dry weight basis) has been obtained. The results indicated that harvesting the crop (*Aristolochia indica*) in second year with 90cm x 90cm spacing with 100:60:100 NPK combination can be considered for getting higher root yield in the agro-climatic condition of the North-East India.

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Conflict of interest statement

Authors declare that they have no conflict of interests.

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