Relative Agronomic performance of different *Dioscorea* species found in different parts of Orissa.

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ABSTRACT: A study was under taken to quantify the relative agronomic performance of twelve *Dioscorea* species (11 wild and one cultivated species *D.esculenta*) found in different parts of Orissa .Various agro morphological character starting from plant height to yield per plant was evaluated among the twelve different *Dioscorea* species and presented in tabular form as per the standard agro metric method.The agronomic character analysis revealed that plant height was significantly superior in *D. hispida* (3.21 m) followed by the shortest height was noticed in *D. oppositifolia* (1.98 m). However at final stage of the crop highest number of leaves are found in *D. oppositifolia* (179) and *D.* wallichii (156). Tuber number per plant was the highest in *D. esculenta* (6.2) and there was only one tuber in *D. bulbifera.* The tuber: shoot ratio was significantly the highest in *D. wallichii* (2.43) and the lowest in *D. oppositifolie* (0.833). The ratio was very low in *D. bulbifera* and *D. hamiltonii* .The yield (kg/plant) was significantly highest in *D. bulbifera* (1.646 kg) and lowest yield was obtained with *D. belophylla* (0.654 kg) followed by *D. Pubera* (0.678 kg). From the study it is concluded that each species has their own identical agronomic character with certain similarities and dissimilarities among themselves. [Nature and Science. 2009;7(3):23-35]. (ISSN: 1545-0740).

Key words: Agro morphology, *Dioscorea*, Growth period, Orissa, Senescence, Tuber

INTRODUCTION

Yams (*Dioscorea* spp.) are tropical tuber crops grown as a source of carbohydrates, but also for use in ceremonial activities (Degras, 1993). They are cultivated world wide, but principally in West Africa, where approximately 95% of world annual production (37 million tones) were achieved in the yam growing belt (FAO, 2004). In East Africa, yams constitute an important subsistence food crop and component of the farming system (Wanyera et al., 1996). Out of six hundred species of *Dioscorea*, so far reported in the world only ten species are in commercial cultivation (Prain and Burkil ,1936). However, some species which are edible, yet, have not been domesticated because of several reasons like inferior quality of tuber, low yield, inaccessible deepest tubers and transformable poisonous forms of tuber. In India so far twenty-six species of *Dioscorea* have been reported (Abruna et al., 1981). At present thirteen *Dioscorea* species are available in Orissa. Out of them two species are cultivated and rest eleven are wild (Maharana ,1993). A study conducted by Niswass (1975) revealed that six *Dioscorea* species are edible in Tumudibandha area of Phulbani district. Arora and Singh (1978) reported that several wild yams are used as food items in the Eastern Ghat region. All the *Dioscorea* species available in the state of Orissa were used as food item as when required. (Martin and Ruberte , 1976).

Out of twelve *Dioscorea* species *D.belophylla, D. glabra, D. hamiltonii, D. oppositifolia, D. pubera, D. wallichii,* twine to right so placed under section *Enantiophyllum* and the rest six species are left twiner. Among them, the compound leave Dioscorea i.e. *D. hispida, D. kalkapershadii,D. pentaphylla* were under the section Lasiophyton . The air yam, *D. bulbifera* is under section opsophyton and *D. esculenta*, the cultivated species is under the section cambilium which produces a cluster of small tuber (Alvarez and Hahn, 1984 ; Coursey and Martin, 1970). In *Dioscorea*, the above ground vegetative mass includes stem, leaf and branch. The stem of yam is rope like structure, and of different shapes depending upon the species specificity. Species under the section *Enantiophyllum* twine to right whereas, others twine to left. Stems grow several meters before any branching occurs and appendages on the stem, like wing, spine, hairs etc., apparently prevent the stem from slipping from its support (Burkill ,1960 ; Coursey , 1967). The research being reported here was aimed at investing the agronomic parameters of different *Dioscorea* species found in different parts of Orissa as a guide to developing a more efficient agro technology and practical system

for yam cultivation.

MATERIALS AND METHODS

Tubers of twelve *Dioscorea* species were collected from different parts of Orissa and the species were grown in the experimental garden, P.G. Deptt. of Botany Utkal University during the year 2004-05 and 2005-06 as per the standard agronomic practices (Ferguson and Gumbs ,1976; Ferguson, 1980 ; Ferguson et al., 1984). Various agro morphological parameters were taken and evaluated as per the standard agro biometric method proposed by Panse and Sukhatme (1978). Harvesting of the tuber was done after all the vines dried and it was done around 300 days after planting. The various agronomic parameters taken in this study are as follows.

Aerial Agro morphological Parameters: Height of the plant was measured in the 1st week of December, when all most all species and cultivars attained the maximum linear growth or reached flowering. The plants were not given full privilege for attaining maximum height since the staking height was restricted to 1.5 meters. The height attained on this staking height was measured only. Average of four plants was taken and this was also followed in all other observations. Number of branches was calculated by counting the branches produced in the main stems and average was taken for computation of data. Number of stem was recorded by counting the main stems produced from the tuber piece planted. Thickness of main stem was measured during December when the branches attained the maximum growth. This was done with the help of dial micrometer and expressed in centimeters. Spread of the plant was measured by keeping a scale in the centre of the stake and average was taken. This relates to the width of entire plant mass attained on 1.5 meters staking system. Number of leaves in different species was counted in the 1st week of December i.e. a period when most of these plants attained maximum growth. Leaf areas of representative leaves were calculated at different stages of plant growth by placing the leaves on a graph paper. A factor was found out showing the relation with the multiplication of length and width. The factor was multiplied with length and width to get the leaf area. Eighth fully expanded leaf from top was only measured. Total leaf area was calculated by taking the average leaf area multiplied by number of leaves. It was calculated for the leaves present during December for both the years. Growth period was recorded in number of days from the date of sprouting of tubers till the vine started to decline. Senescence of first leaf in the vine was calculated by counting the days from the date of planting to the date when first leaf turned to yellow under natural condition but not by any disease.

Under Agronomic ground Parameters: Tuber initiation time was recorded in weeks by exposing the plants carefully and six weeks afterwards at week's interval in some extra observation plants. Root zone was measured by removing the soil carefully and tracing the root around the plant in four direction just before decline of the vine**.** Tuber to shoot ratio was calculated by harvesting the tuber just at the time of decline of the vine and by weighing the tuber and the vegetative growth. Number of tubers produced in each plant was calculated on the basis of number of tuber produced in the plants under observation. Length of tuber was measured in cm from the neck of the tuber to the basal tip of the tuber. Width of tuber was measured at three point's i.e. basal, middle and top portion and average was taken for tabulation of data. Tuber formation depth was assessed by measuring the soil depth from plain surface of soil to the depth where the tuber was formed. Immediately after harvest the tubers from observation plants were cleaned of soils adhered to it and weighed. Mean was taken for tabulation of data.

RESULT AND DISCUSSION

Result of the experiment: Data collected on various characters for the 11 wild and one cultivated *Dioscorea* species were analyzed for the respective years i.e. first year and second year. The pooled data was analyzed basing on six replications of two years. However, the I and II year data were given along with the pooled data for reference only (Lyonga and Ayuktaken , 1982; IJOYAH et al., 2006; Law-Ogbomo, 2007).

Result of the Aerial Agro morphological Parameters : Significant difference was observed for plant height in both the years and in pooled data also. Height was significantly superior in *D. hispida* (3.21 m) followed by *D. pubera* (3.21m) and *D. bulbifera* (3.05 m). However, significantly shortest height was

noticed in *D. oppositifolia* (1.98 m). *D. esculenta* (cultivated species) attained a height of 2.67 m only(Table-1). Out of 11 wild species only two species were having profuse branching habit i.e. *D. wallichii* (29.66) and *D. glabra* (21.58) and these two differed significantly. Among other species, *D. oppositifolia* was having the highest number of branches (10.50) and rest species were having less than 10 numbers of branches. Majority of the species were having 4-5 branches and no significant difference was observed between them (*D. pubera, D. belophylla, D. tomentosa, D. pentaphylla, D. kalkapershadii, D. hispida and D. bulbifera*). *D. esculenta* produced a good number of branches (8.9 / plant) (Table-1).Out of 12 species, 6 species produced a single stemmed plant. *D. oppositifolia* had significantly the highest number of stems (2.04/plant) followed by *D. esculenta* (1.05/ plant) and these two differed significantly (Table-1). Significant difference was observed for thickness of the main stem in both the years and pooled data. The stems were significantly of highest diameter in *D. hispida* (0.70cm) followed by *D. bulbifera* (0.69) and was no significant difference was observed between these two species. The stem diameter was shortest in *D. hamiltonii* (0.26 cm) followed by *D. oppositifolia* (0.27 cm) (Table-2). Number of leaves were counted at 2 month, 3 month, 4 month and at final growth phase. Significant difference was observed in I year, II year and pooled data. Significantly highest numbers of leaves were produced in *D.esculenta* at 2 months (56.79), 3 months (103.75), 4 months (162.06) and final stage (211.91). At all these stages, the next highest number of leaves was observed in *D. oppositifolia*. At 3 month stage all the species except the above two species produced less than 100 number of leaves per plant. At final stage, the leave number was more than 100 in all species of which *D. esculenta* only had more than 200 leaves per plant (211). However, *D. oppositifolia* (179) and *D. wallichii* (156) had good number of leaves at final stage (Table-2, 3). *D. wallichii* was the most spreading species (203.45 cm) which differed significantly with all other species. The least spreading species was *D. belophylla* (34.58 cm) which was at par with *D. hamiltonii* (35.41), *D. tomentosa* (44.50), *D. pentaphylla* (37.16cm), *D. kalkapershadii* (35.54cm), *D. hispida* (35.75cm) and *D. bulbifera* (41.45cm) (Table-4). Total leaf area (single side) was significantly highest in *D. wallichii* (30186 sq. cm) followed by *D. pubera* (21393 sq. cm) as compared to all the species but these two also differed significantly. The lowest total leaf area was recorded in *D. hamiltonii* (3280 sq. cm) followed of *D. oppositifolia* (3498 sq. cm) and these two were at par with *D. tomentoa* (8561sq.cm) and *D. pentaphylla* (7703 sq.cm) (Table-4). Significant difference was observed for the starting time of senescence of 1st leaf. The pooled data revealed that senescence time of 1st leaf was significantly earliest in *D. hispida* (94.91 days) followed by *D. bulbifera* (95.37 days) and *D. oppositifolia* (96.91 days) and all these were at par. The senescence was significantly delayed in *D. pentaphylla* (128.95 days) followed by *D. belophylla* (121.00 days) and significant difference was observed between these two (Table-6). Significant difference was observed for active growth period. Shortest period was observed with *D.bulbifera* (153.97days), followed by *D. kalkapershadii* (165.25 days) and *D. oppositifolia* (167.16 days).No significant difference was observed between *D.kalkapershadii*(165.25),*D.hispida* (169.08) and *D.oppositifolia* (167.16). Similarly no significant difference was observed among *D.hamiltonii* (193.00), *D.glabra*(192.08) and *D.pubera* (195.20) and also among *D. belophylla* (183.58), *D. tomentosa* (181.66) and *D. pentaphylla* (184.66) (Table-6).

Result of the Under ground Agronomic Parameters: Spread of root zone was significantly highest in *D. wallichii* (95.98 cm) followed by *D. glabra* (82.80 cm) and significant difference existed between them. The root zone was shortest in *D. habiltonii* (16.87 cm) followed by *D. belophylla* (21.66 cm) and significant difference was observed between them (Table-5).It was observed that the tuber initiation time was significantly different in different species under study and in both the years and in pooled data. It was earliest in *D. hispida* (5.79 weeks) followed by *D. bulbifera* (6.62 weeks) and there was significant difference between these two species. It was most delayed in *D. belophylla* (11.45 weeks) followed by *D. glabra* (10.45 weeks) and *D. esculenta* (10.41 weeks) and there was no significant difference between these two (Table-6).Tuber formation depth was significantly lowest in *D. pentaphylla* (11 cm) followed by *D. kalkapershadii* (11.66 cm) and *D. hispida* (16.87 cm). No significant difference was observed in the former two. Tuber formation depth was deepest in *D. belophylla* (43.62 cm) followed by *D. wallichii* (43.08 cm) and *D. hamiltonii* (41.70 cm), and all these species were at par. The depth was 24.6 cm and 22.5 cm respectively in *D. bulbifera* and *D. esculenta* (Table-7).Tuber length was significantly shortest (8.81 cm) in *D. esculenta* and the longest in *D. tomentosa* (60.48 cm).Tubers below 20 cm long were observed in *D. hispid* and *D. bulbifera* and beyond 40 cm was in *D. oppositifolia, D. glabra, D. wallichii* and *D. pentaphylla* (Table-7). Tuber width was significantly shortest in *D.oppositifolia* and *D.*

glabra (3.11 cm) followed by *D. pubera*, *D. tomentosa* (3.78 cm), *D. esculenta* (3.8 cm). Tuber width was significantly highest in *D. hispida* (16.86 cm) as compared to other species. However, *D. pentaphylla* (11.26 cm) and *D. bulbifera* (10.99 cm) significantly differed from each other (Table-8). Tuber number per plant was the highest in *D. esculenta* (6.20) followed by *D. glabra* (4.12) and these two differed significantly from each other. There was only one tuber in *D. bulbifera*, *D. hispida*, *D. kalkapershadii* and *D. pentaphylla* while it was one or two in *D. oppositifolia*, *D. hamiltonii* and *D. pubera* (Table-8). The tuber: shoot ratio was significantly the highest in *D. wallichii* (9.08) followed by *D. glabra*(7.89) and the lowest in *D. oppositifolie* (0.833). The ratio was very low in *D. bulbifera* (1.06) and *D. hamiltonii*(1.04) (Table-9).Significant difference was observed for yield in both the years and in pooled data. The yield was significantly highest in *D. bulbifera* (1.646 kg) followed by *D. glabra* (1.091 kg), *D. tomentosa* (1.074 kg), *D. pentaphylla* (1.060 kg) and *D. esculenta*(1.022kg).The lowest yield was obtained with *D. belophylla* (0.654 kg) followed by *D. Pubera* (0.678 kg) (Table-9).

Table.1.Plant height(m) ,Branch number, Number of main steams /plant and Thickness of main stem (cm) in different *Dioscorea* species

Sl. No.	Name of the species	Plant height (m)			Branch number /plant			Number of main steams /plant			Thickness of main stem (cm)		
		I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
1	*D.belophylla*	2.403	2.303	2.353	4.583	4.250	4.417	1.000	1.000	1.000	0.423	0.427	0.425
2	*D.bulbifera*	3.217	2.883	3.050	4.167	5.667	4.917	1.083	1.083	1.083	0.703	0.693	0.698
3	*D. esculenta*	2.917	2.433	2.675	9.250	8.667	8.958	1.583	1.417	1.500	0.310	0.313	0.312
4	*D.glabra*	2.417	2.567	2.492	21.917	21.250	21.583	1.000	1.000	1.000	0.510	0.500	0.505
5	*D.hamiltonii*	2.797	2.833	2.815	4.833	4.750	4.792	1.083	1.250	1.167	0.273	0.257	0.265
6	*D.hispida*	3.450	2.983	3.217	4.667	4.500	4.583	1.000	1.000	1.000	0.723	0.690	0.707
7	*D.kalkapershadii*	3.237	2.517	2.877	4.417	4.833	4.625	1.000	1.000	1.000	0.337	0.337	0.337
8	*D.oppositifolia*	2.137	1.833	1.985	11.667	9.33	10.500	2.000	2.083	2.042	0.273	0.267	0.270
9	*D.pentaphylla*	2.823	2.900	2.862	4.500	4.917	4.708	1.000	1.000	1.000	0.337	0.337	0.337
10	*D.pubera*	3.237	3.183	3.210	8.167	6.833	7.500	1.083	1.333	1.208	0.377	0.367	0.372
11	*D.tomentosa*	2.197	1.823	2.010	5.667	4.250	4.958	1.000	1.000	1.000	0.327	0.320	0.323
12	*D.wallichii*	2.820	3.050	2.935	31.333	28.000	29.667	1.500	1.250	1.375	0.443	0.447	0.445
'F' test		Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
C.D. (0.05)		0.262	0.3515	0.2494	0.2698	2.4162	1.324	0.3858	0.2845	0.2308	0.0141	0.0169	0.119

Table.2. Number of leaves at 2 month and 3 month stage in different *Dioscorea species*.

Sl. No	Name of the species	Number of leaves at 2 months			Number of leaves at 3 months		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	43.833	44.083	43.958	86.033	90.000	88.017
2	*D.bulbifera*	26.833	24.500	25.667	54.667	54.933	54.800
3	*D. esculenta*	56.583	57.000	56.792	99.000	108.500	103.750
4	*D.glabra*	26.417	27.167	26.792	72.000	72.233	72.117
5	*D.hamiltonii*	37.337	38.750	38.042	84.833	96.000	90.417
6	*D.hispida*	24.167	29.167	26.667	64.333	72.167	68.250
7	*D.kalkapershadii*	20.333	21.833	21.083	51.000	48.167	49.583
8	*D.oppositifolia*	66.583	62.750	64.667	105.083	105.083	105.083
9	*D.pentaphylla*	31.500	32.500	32.000	57.167	56.167	56.667
10	*D.pubera*	20.750	21.833	21.292	68.417	66.167	67.292
11	*D.tomentosa*	26.833	25.000	25.917	54.000	60.333	57.167
12	*D.wallichii*	34.250	37.833	36.042	67.333	75.833	71.583
'F' test		Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
C.D. (0.05)		5.354	4.4345	3.4916	5.198	8.162	5.424

Table.3. Number of leaves at 4 month and final crop growth stage in different *Dioscorea species*

Sl No.	Name of the species	Number of leaves at 4 months			Number of leaves at (25 weeks) final stage		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	109.417	109.750	109.583	143.167	137.083	140.125
2	*D.bulbifera*	84.000	86.500	85.250	112.500	115.500	114.000
3	*D. esculenta*	162.217	161.917	162.067	213.833	210.000	211.917
4	*D.glabra*	86.833	88.833	87.833	111.083	116.250	113.667
5	*D.hamiltonii*	105.167	108.250	106.708	133.250	128.417	130.833
6	*D.hispida*	90.233	87.667	88.950	116.333	117.417	116.875
7	*D.kalkapershadii*	79.333	79.083	78.708	97.917	105.333	101.625
8	*D.oppositifolia*	135.583	135.167	135.375	188.333	170.083	179.208
9	*D.pentaphylla*	78.667	79.000	78.833	116.083	126.000	121.042
10	*D.pubera*	80.167	82.667	81.417	107.833	106.583	107.208
11	*D.tomentosa*	74.917	76.833	75.875	104.250	102.583	103.417
12	*D.wallichii*	104.583	100.500	102.542	157.917	154.167	156.042
'F' test		Sig. **	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
C.D. (0.05)		8.344	9.021	5.6831	10.215	15.414	9.588

Table.4. Spread of plant and leaf area (single side) in different *Dioscorea* species.

Sl. No.	Name of the species	Spread of plant (cm)			Leaf area/plant (sq.cm)		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	36.167	33.000	34.583	18106.250	18799.000	18452.630
2	*D.bulbifera*	41.167	41.750	41.458	16123.170	16802.420	16462.790
3	*D. esculenta*	52.833	52.667	52.750	16350.170	11378.080	13864.130
4	*D.glabra*	173.583	190.250	181.917	5491.834	5485.500	5488.667
5	*D.hamiltonii*	35.250	35.583	35.417	3308.667	3251.667	3280.167
6	*D.hispida*	35.667	35.833	35.750	18665.170	19446.670	19055.920
7	*D.kalkapershadii*	35.750	35.333	35.542	13448.500	14026.170	13737.330
8	*D.oppositifolia*	56.917	61.500	59.208	3533.083	3463.500	3498.292
9	*D.pentaphylla*	39.500	34.833	37.167	7055.584	8351.000	7703.292
10	*D.pubera*	44.000	55.167	49.583	22489.170	20297.580	21393.380
11	*D.tomentosa*	45.333	43.667	44.500	8659.000	8463.750	8561.375
12	*D.wallichii*	218.333	188.583	203.458	29991.920	30380.670	30186.290
'F' test		Sig. **	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
C.D. (0.05)		16.287	13.642	11.944	1767.9	1658.1	2719.5

Table.5. Starting time of senescence of 1^{st} leaf and diameter of root zone in different *Dioscorea species*.

Sl. No.	Name of the species	Start of senescence in 1^{st} leaf (Days)			Diameter of root zone (cm)		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	120.833	121.167	121.000	18.400	24.933	21.667
2	*D.bulbifera*	96.000	94.750	95.375	33.267	37.433	35.350
3	*D. esculenta*	110.667	109.917	110.292	24.000	31.967	27.983
4	*D.glabra*	119.000	120.667	119.833	75.300	90.300	82.800
5	*D.hamiltonii*	112.500	113.833	113.167	16.700	17.033	16.867
6	*D.hispida*	96.667	93.167	94.917	23.567	27.400	25.483
7	*D.kalkapershadii*	103.333	121.333	112.333	34.300	35.367	34.833
8	*D.oppositifolia*	96.167	97.667	96.917	21.700	29.567	25.633
9	*D.pentaphylla*	133.167	124.733	128.950	35.700	40.433	38.667
10	*D.pubera*	114..667	113.667	114.167	28.800	30.500	29.650
11	*D.tomentosa*	117.833	107.417	112.625	58.467	72.467	65.467
12	*D.wallichii*	113.667	110.917	112.292	91.300	100.667	95.983
'F' test		Sig. **	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
C.D. (0.05)		7.373	12.5159	7.935	0.2806	3.8086	3.544

Table.6.Tuber initiation time and growth period in different *Dioscorea* species.

Sl. No.	Name of the species	Tuber initiation time (weeks)			Growth period (Days)		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	11.417	11.500	11.458	184.583	182.583	183.583
2	*D.bulbifera*	6.335	6.917	6.625	155.083	152.867	153.975
3	*D. esculenta*	10.083	10.750	10.417	177.750	171.000	174.375
4	*D.glabra*	10.500	10.417	10458	191.167	193.000	192.083
5	*D.hamiltonii*	9.500	10.250	9.875	192.000	190.000	193.000
6	*D.hispida*	5.417	6.167	5.792	166.583	171.583	169.083
7	*D.kalkapershadii*	8.167	8.167	8.167	161.333	169.167	165.250
8	*D.oppositifolia*	8.250	8.917	8.583	163.083	171.250	167.167
9	*D.pentaphylla*	7.333	7.417	7.375	184.583	180.750	184.667
10	*D.pubera*	7.167	7.583	7.375	194.583	195.833	195.208
11	*D.tomentosa*	6.333	7.417	6.875	182.917	180.417	181.667
12	*D.wallichii*	10.417	10.083	10.250	181.8333	174.750	178.292
'F' test		Sig.**	Sig. **	Sig.**	Sig.**	Sig.**	Sig. **
C.D. (0.05)		0.3204	1.0379	0.5611	1.0601	7.848	4.851

Table.7.Tuberformation depth and length of tuber in different *Dioscorea* species.

Sl. No.	Name of the species	Tuber formation depth (cm)			Length of tuber (cm)		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	46.500	40.750	44.625	20.167	20.100	20.133
2	*D.bulbifera*	24.167	25.167	24.667	15.700	15.533	15.617
3	*D. esculenta*	22.667	22.333	22.500	8.700	8.933	8.817
4	*D.glabra*	34.583	35.500	35.042	45.267	34.067	44.667
5	*D.hamiltonii*	40.917	42.500	41.708	33.167	30.933	32.080
6	*D.hispida*	16.667	17.083	16.875	19.250	20.700	19.975
7	*D.kalkapershadii*	11.917	11.417	11.667	26.533	26.100	26.317
8	*D.oppositifolia*	39.417	35.500	37.458	43.500	37.083	40.292
9	*D.pentaphylla*	11.333	10.667	11.000	44.067	44.500	44.283
10	*D.pubera*	31.500	32.667	32.583	38.900	36.533	37.717
11	*D.tomentosa*	19.833	42.000	20.917	61.400	59.567	60.483
12	*D.wallichii*	41.833	44.333	43.083	46.867	43.600	45.233
'F' test		Sig. **	Sig.**	Sig.**	Sig.**	Sig. **	Sig. **
C.D. (0.05)		3.853	5.675	3.481	7.453	4.905	4.229

Table.8.Width of tuber and number of tubers in different *Dioscorea* species.

Sl. No.	Name of the species	Width of tuber (cm)			No. of tubers / plant		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	4.033	3.933	3.983	2.000	2.167	2.083
2	*D.bulbifera*	10.650	11.333	10.992	1.000	1.000	1.000
3	*D. esculenta*	3.867	3.733	3.800	6.417	6.000	6.208
4	*D.glabra*	2.967	3.267	3.117	4.417	3.833	4.125
5	*D.hamiltonii*	7.800	7.633	7.767	1.083	1.250	1.167
6	*D.hispida*	16.667	16.467	16.867	1.000	1.000	1.000
7	*D.kalkapershadii*	5.500	5.700	5.600	1.000	1.000	1.000
8	*D.oppositifollia*	3.100	3.133	3.117	1.250	1.167	1.208
9	*D.pentaphylla*	11.200	11.333	11.267	1.000	1.000	1.000
10	*D.pubera*	3.833	3.733	3.783	1.667	2.000	1.833
11	*D.tomentosa*	3.633	3.933	3.783	3.417	3.250	3.333
12	*D.wallichi*	4.667	4.333	4.500	2.500	2.333	2.417
'F' test		Sig. **	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
CD (0.05)		1.0785	0.644	0.188	0.658	1.099	0.5964

Table.9. Shoot: Tuber ratio and plant yield in different *Dioscorea* species. [*Including bulbuil]

Sl. No.	Name of the species	Shoot tuber ratio			Yield (kg/plant)		
		I	II	Pooled	I	II	Pooled
1	*D.belophylla*	1.393	1.417	1.400	0.703	0.605	0.654
2	*D.bulbifera**	1.047	1.083	1.065	1.560	1.732	1.646
3	*D. esculenta*	1.267	1.203	1.235	1.026	1.018	1.022
4	*D.glabra*	7.950	7.833	7.892	1.057	1.124	1.091
5	*D.hamiltonii*	1.040	1.050	1.045	0.759	0.780	0.770
6	*D.hispida*	3.357	3.700	3.528	0.934	0.936	0.935
7	*D.kalkapershadii*	2.157	2.300	2.228	0.937	0.901	0.919
8	*D.oppositifolia*	0.783	0.833	0.808	1.056	0.844	0.950
9	*D.pentaphylla*	2.450	2.420	2.435	1.182	0.937	1.060
10	*D.pubera*	1.633	1.483	1.558	0.703	0.653	0.678
11	*D.tomentosa*	1.243	1.267	1.255	1.084	1.064	1.074
12	*D.wallichi*	9.150	9.010	9.080	1.041	0.867	0.954
'F' test		Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig. **
CD(0.05)		0.783	0.667	1.8372	0.232	0.124	0.141

DISCUSSION

From the various agronomic aspect of the study it is concluded that right twining species are normally shorter than left twining species. Prain and Burkill (1936), Singh and Arora (1978) reported that out of several wild species growing in the jungles of Orissa *D. bulbifera* and *D. hispida* climbs up to 15 meters. But in this investigation, all the species are forced to grow with limited staking. Therefore the plant height is reduced to 20-50 percent of the height observed in nature. *D. oppositifolia* and *D. tomentosa* produced the shortest vine length respectively 1.9 meter (m) and 2.01 m whereas *D. hispida* (3.21m) and *D. pubera* (3.21 m) attained highest linear growth. *D. wallichii* produced highest number of branches (29.66 branches) followed by *D. glabra* (21.58 branches). *D. esculenta* and *D. oppositifolia* produced 8.9 and 10.5 number of branches respectively. Other species produced less than 8 branches per vine. It is clear from the study that a yam plant should produce around 10 numbers of branches for proper growth of 8000-10000 vines in a hectare to get ample sunlight (Okpara and Omaliko, 1995). Staking plants of *P.tetragonolobus* affects vegetative and reproductive growth but tuberous roots (number and size) were not clearly affected, although in other species such as *Dioscorea* species, this treatment strongly favors tuber number and size of individual tubers (Enyi,1972a ; Igwilo, 1989; Ndegwe et al, 1990).

Thick stems of a yam help to cling the stake properly. In the present study, *D. bulbifera* (0.69 cm), *D. hispida* (0.7 cm) and *D. glabra* (0.5 cm) produce stems more than 0.5 cm thick. The thin and wiry branches of few species trails on ground unless staking is provided at early stage. The canopy of vines in left twining species is low, nearly 50% of the right twining species. *D. glabra* (181 cm) and *D. wallichii* (208 cm) spread up to 2 m. where as, all other species restricted their canopy within 60 cm. A crowding leaf mass reduce the rate of photosynthesis due to flat leaves, restricted sunlight and low stomatal opening. As many of the *Dioscoreas* are not having erect leaves for which a low canopy may allow penetration of more sunlight for higher photosynthesis (Ramirez and Rodriguez, 1975).The leaf production ability of right twining species is higher than left twining species. At final count (25 weeks after planting) the average leave number was 137 and 128 respectively in right and left twining species (Table -3, 4). But leaf number was highest in *D. esculenta* (211) followed by *D. oppositifolia* (179).

In this trial, senescence process is quicker in left twining species (109.08 days) than right twining species (112.89 days, Table 37). Surprisingly species like *D. hispida, D. bulbifera and D. oppositifolia* start senescence before 100 days of crop growth. Leaf production was lowest in *D. kalkapershadii* (101) followed by *D. tomentosa* (103). All *Dioscorea* having compound leaves produced less number of leaves (103-121). In *D. glabra* and *D. pubera* respectively produced 117 and 107 leaves per plant. However, the total leaf area was highest in *D. wallichii* (30186 sq. cm) and *D. pubera* (21393 sq. cm) because of their large leaf. Leaf area index (LAI), photosynthesis ability, short prebulking period are important in all *Dioscorea*. Flach (1979) reported four phases in yam development namely (1) establishment, (2) development of leaf area, (3) starch accumulation, (4) ripening i.e. diminishing of leaf area accompanying starch accumulation and these phases are in 6 weeks, 11 weeks, 8 weeks and 14 weeks duration respectively. Therefore, it is important to select a cultivar which completes the first and second phase in a shorter period following a rapid bulking and maturation period. However, Degras (1976) proved that bulking is initiated in first phase itself. Quamina et al (1982) also reported same finding. Haynes et al (1967) believed that in *D. alata,* leaf area decreases as tuberization begins. In the present investigation tuber initiation time was earliest in *D. hispidda* (5.79) weeks) followed by *D. bulbifera* (6.62 weeks) and *D. tomentosa* (6.8 weeks). Species having earlier tuber initiation yielded higher because of a longer bulking period.

Data recorded on diameter of root zone revealed (Table -5) that root zone is wider in right twining species (45.43 cm) than left twining species (37.86 cm). It is highest in *D. glabra* (82 cm) followed by *D. wallichii* (95.98 cm) and *D. tomentosa* (65.46 cm). Lowest was recorded in *D. hamiltonii* (16.87 cm) followed by *D. belophylla* (21.66 cm). In right twining species the yield was reduced proportionately with

reduced root zone and same trend was also observed in left twining species, but in a lesser degree. Ferguson et al., (1976) reported that compaction in root area reduced the yield of tuber in *D. alata* by reduced leaf growth. Formation of tuber in a yam is the most peculiar feature. In the present study, the tuber initiation was quickest in *D. hispida* (5.79 weeks) followed by *D. bulbifera* (6.62 weeks). On an average, most of the left twining species initiated tuber formation earlier (7.54 weeks) when compared to the right twining species (9.66 weeks). However *D. belophylla* (11.45 weeks), *D. wallichii* (10.25 weeks) and *D. esculenta* (10.41 weeks) are very late to initiate the tuber formation.

As observed, the initiation of senescence process is significantly earliest in *D. oppositifolia* (96.91 dys) followed by *D. bulbifera* (95.37 days) and *D. hispida* (94.91 days). Earlier senescence is observed in a yam where tubers form close to soil moisture surface and produce a good number of leaves or easily prone to moisture stress. *D. bulbifera* produces a good amount of bulbils and *D. hispida* tubers are produced very close to soil surface (16.87 cm) where as *D. pentaphylla* and *D. belophylla* tubers are deep seated. As a result, they are late to start the senescence phase. Above all, the start of senescence and growth period are highly variable among the species ranging 94-128 days and 153-195 days respectively. Several good characters required for an ideal yam farming as observed in *D. hispida*. Since it is a poisonous one search may be made to locate non poisonous types. *D. dumetorum* an African species akeen to *D. hispida* has several non poisonous forms.

All yams under the section *Enantiophyllum* produce tubers at an average depth of 38.9 cm as compared to 17.93 cm in left twining species. Shallow seated tubers are easy to harvest and they effectively utilize the nutrients and soil moisture. However, all functional roots are clustered around the neck. All species under section *Lasiophyton* are shallow seated. Tubers of *D. pentaphylla* are formed very close to soil surface (11 cm) so also *D. kalkapershadii* (11.41 cm). *D. belophylla* produced tubers at highest depth (43.62 cm) so also in *D. wallichii* (43.08 cm) and *D. hamiltonii* (41.70 cm). Tubers of all yams under section *Enantiophyllum* measure in between 20.13 cm to 45.23 cm whereas in left twining species the length is in between 8.81 cm to 60. 48 cm. *D. esculenta* tubers measure 10 cm in length, whereas, tubers of *D. tomentosa* are the longest (60.48 cm). *D. hispida* and *D. bulbifera* are ideal type yams as regard to length and width of tuber. *D. esculenta* also possess a good shape in this regard. Most of the yams grown and marketed in Africa and Latin America are of medium length which facilitate for their proper storage and marketing. Such tubers are ideal for transportation. Martin et al (1974) reported that ideal yam cultivars should bear in pair or threes and spherical or cylindrical in shape, not often branched and have smooth but thickened skin that resists abrasion. Number of tuber per plant is highest (6.2) in *D. esculenta*, a member of *Cambilium*. Also tubers are more in *D. glabra* (4.12). In yams, shape of tuber in a particular variety is important as the number of tuber. A tuber should be of within 30 cm length and weighs up to 1-2 kg. None of the species produce tubers suitable for marketing except *D. hispida*, *D. pentaphylla* and *D. kalkapershadii*. The tuber of *D. oppositifolia* are very long for which they break into small pieces during harvesting. *D. pubea* produces less leaves (107.2) with comparison to other species. This favors for longer vine life and late to start senescence (114 days after sprouting). *D. oppositifolia* during its growth period produces 179.2 leaves. The *Disocorea* with more leaves maintains a longer growth period. Species with shorter growth period yield more as observed in *D. bulbifera* and *D. hispida*. A short prebulking period with early tuber initiation are observed in them. Growth and developmental process in yams have studied by Campbell (1962), Enyi (1972b), Sobul (1972), Sadik and Okereke (1975) Degras et al. (1977) and Oyolu (1982), and it was opined that a yam plant should be of a short duration with high yield. All the 12 species were observed for crop duration over 2 years and it is revealed that left twining species are shorter duration (171.5 days) than right twining species (184.88 days). Among the right twining species *D. oppositifolia* and except *D. tomentosa* and *D. pentaphylla* other left twining species exhibited less than 180 days duration. The shortest growth period was observed in *D. bulbifera* (153.9 days) followed by *D. Kalkapershadii* (165.25 days) and *D. oppositifolia* (167.16 days). Species having more than six months growth period are *D. pubera* (195.2 days), *D hamiltonii* (193 days) and *D. glabra* (192.0 days).

Many wild *Dioscorea* could not be domesticated primarily due to their poor yield and tubers of inferior quality. Among the wild species, highest yield was recorded in *D. bulbifera*(1.646 kg) where 70 % yield contributed by bulbils. The study reveals that yield is higher in species with shallow seated tubers than deep seated tubers. Tubers with wiry shape are poor yielder. The average yield per plant is 850 gm in

right twining species (Table -9) and 1.11 kg in left twining species. Therefore, many species under *Enantiophyllum* remained in obscurity due to poor yield. Similarly, many left twining species with good yield could not be domesticated owing to tubers of poor quality. *Dioscorea* species yielded more than one kg tuber per plant are *D. glabra, D. tomentosa, D. pentaphylla, D. bulbifera* and *D. esculenta*. Very little information is available on the yield potential of different wild species found in Orissa. The yield is very low in *D. belophylla* (0.654 kg) because of deep seated tuber i.e. 43.62 cm, highest among all. Species with deepest tubers invariably suffer from moisture stress. Further, a moderate to low shoot: root ratio is favorable for yield (Sivan, 1980). The yield in *D. wallichii* is only 0.954 kg/plant with the highest shoot root ratio of 1: 9.080 on the other hand *D. oppositifolia* yielded 0.950 kg/plant with a shoot root ratio of 1: 0.808. More vegetative growth in a tuber crop requires more photosynthates for maintenance of vegetative part hence produce a poor tuber yield. *D. tomentosa* and *D. pentaphylla* yielded more than 1 kg/ plant of tuber. However, yield of tuber is not the only criteria for selection of species; rather the quality of the tuber plays an important role for domestication. Tubers of *D. oppositifolia*, *D. hamiltonii*, *D. belophylla*, *D. wallichii* and *D. tomentosa* are of very good quality. *D. pentaphylla* and *D. Kalkapershadii* tubers are inferior and fibrous in nature (Leon , 1976; Lyonga and Ayuktaken, 1982). The ability to form tubers is, in the first instance, dependent on the genetics of the variety (Martin, 1978) and is affected by environmental factors such as day length, temperature and some cultivation practices including species specific character (King & Risimeri, 1992).

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