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Influence of Manure and Plant Spacing on Growth and Yield of *Dioscorea deltoidea* Wall: an Endangered Species

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A field experiment was conducted during 2006 to 2010 to evaluate application of farm yard manure (FYM, 15, 30 and 45 t/ha) and spacing (25cm x 25cm, 25cm x 50 cm and 50cm x 50 cm) on crop growth, bio-mass and rhizome yield of *Dioscorea deltoidea*. Sprouting numbers were recorded from 0 to 43 days. As per statistical analysis, 60.56 plants were sprouted after 36 days, maximum in FYM 45 t/ha. However, all results were in increasing order and in terms of spacing (50cm x 50cm), it was 63.22, statistically significant after 43 days. In the spacing the sprouting and plant length was found in increasing order. The plant length was 96.63 cm maximum in 45t/ha after 43 days. In the FYM treatment and used spacing, all the results were statically significant. In the case of fresh weight of crop was statistically significant in terms of different application of FYM and spacing. The highest fresh weight was 15.82, 38.76 and 59.72 t/ha recorded in FYM 45 t/ha and 18.47, 41.53 and 62.58 t/ha in spacing 50cm x50cm, in 2nd, 3rd and 4th year, which are statistically significant. The diosgenin content was consistent on dry weight basis.

Keyword: *Dioscorea deltoidea,* FYM, Spacing, Biomass, Diosgenin.

1. Introduction

Dioscorea species belongs to family *dioscoreaceae*. It is a multi species tuber crop distributed in Africa, Asia, parts of South America, South pacific islands and in Caribbean. In Asia, the crop is found mainly in Afghanistan, Bhutan, Cambodia, China, India (western Himalaya), Nepal, Pakistan, Thailand, Vietnam. Its habitat is found ranging from 450 to 3100 m altitude in Nepal (Olsen & Larsen, 2003). In indian Himalaya it is found between, 1700 – 2800 m, in Arunachal Pradesh, Assam, Sikkim, Himachal Pradesh and Uttarakhand, Meghalaya (LOC 1986, Nayar & Sastry 1988, Pradhan 1993, Rastogi and Pant 2004). Asiedu (2010) has reported its food status for millions of people in tropical and sub-tropical regions in West and Central Africa. Among the Dioscorea species, *D. deltoidea*, is a commercial crop of medicinal importance.

In Himachal Pradesh, Uttarakhand and Jammu & Kashmir, Ved. et.al., (2003) has reported its declining status due to over harvesting in forests for its use in natural medicine. Rawat (2005) and Kaul (2005) reported that *D. deltoidea* is threatened in natural habitats due to illegal and over exploitation by local population for trade and domestic use. *D. deltoidea* is categorized in India as vulnerable for Red Data Book of Indian plants (Nayer and Sastry, 1988). It was assessed as critically endangered in 1998, after a survey (Molur and Walker, 1998) was reported decline of 80% of its population in wild.

Due to wide medicinal applications, *D. deltoidea* has tremendous importance in Asia, Nepal, Bhutan, northern India, Pakistan and South western China, (Saeed, 1997). Anon, (2002a) has reported that diosgenin content in *D. deltoidea* rhizomes is used as precursor for the synthesis of important steroid hormones like progesterone, corticosteroids and anabolic steroids. Husain *et. al.*, (1979) has reported sapogenins diosgenin and yamogenin, 8-10% sapogenin is reported (Morton, 1977) and 4.8% diosgenin is reported (Chopra *et.al.,* 1986) in *D. deltoidea*. *Dioscorea deltoidea* is used in traditional medicine and as a source of steroidal drug in western India (Jain, 2005).

Because of commercial importance, of its rhizomes, as it is used in the treatment of round worm and anti-rheumatic properties; the demand of *D. deltoidea* rhizomes is met only from wild sources. Some reports are available in literature regarding its cultivation, but according to Molur and Walker (1998), there is no large scale commercial cultivation in India. Samant *et al.,* (1998) have established propagation protocols through tissue culture.

Globally *D. deltoidea* has been recognized as an important crop due to its traditional medicinal use and ethno-botanical applications; it is in high demand in African countries as food security for more than 60 million people (Asiedu and Sartie, 2010). Presently *D. deltoidea* is critically endangered species in Asian countries. The present study was conducted to develop agro technique package using different level of FYM and plant spacing for sustainable production of the crop growth and yield. The rhizomes of this crop are used for the production of various commercial products by pharmaceutical industries.

2. Materials and Methods

Field experiment was conducted during 2006 to 2010 at the experimental farm of CSIR-IHBT Palampur (1350m).

The soil of the experimental site was silty clay loam and acidic (pH 6.4). The soil was high in available organic carbon N and P, while K was low.

The plant material (rhizomes) was collected from forest region of Kandbari area. The rhizomes were 1.5 cm to 3.0 cm in thickness and 4.0 cm to 5.0 cm in length. The fresh weight of ten no. rhizomes was 125 g. Rhizomes used for experimental purposes were more or less same in length and thickness. A field trial was laid on December 13, 2006 using three level of FYM (F1;15,F2;30 and F3;45 t/ha) and three spacing viz. S1;25 x25cm, S2;25 x 50cm and S3;50 x 50cm. The design of the experiment was two factor factorial in randomize complete block having 9 treatments and 3 replications. The unit plot size was 4m x 4m. The crop was raised by rhizomes of uniformed size and average weight (12-13g.).

The observation of plant density and plant length were recorded. The fresh weight of rhizomes was measured 2nd, 3rd and 4th year during December 2008, 2009 and in 2010. Dry weight of rhizomes from all the treatments was recorded. The diosgenin content was evaluated on dry weight basis.

All the recorded parameters were statistically analyzed using STATIASTCA-7 software.

3. Results

The experiment was laid out during December 2006, in experimental farm. As per the agro climatic conditions of this region, the dormant period is from November to March. The temperature and other climatic conditions were in the range of 22^0c to 26^0c in the day time of April. From April onwards new growth was observed during the vegetative phase. Occasionally, some time the weather became hot about temperature increased upto 26^0c in the last week of March, as the 1st start of sprouting of rhizomes was recorded on March 2007 and recorded upto 2nd may 2007, the parameters were recorded at the interval of every 7 days. After some time, the sprouting converted in to the cluster growth and tender stem branches were came out from main stems (fig. 1). In the year 2008 and 2009 the sprouting was at different time as per agro climatic conditions of the region. In keeping view of different time of sprouting from year to year, as per the local agro-climatic conditions, the interval of days has been adopted for recording the growth parameters. For better growth we have used stakes (wooden) to support the climber of the crop (fig. 2).

Fig 1: Experiment trial in the field in the month of June

Fig 2: Experiment trial in the field in the month of August

Since beginning (0 days) the maximum number of sprouts were recorded in the high dose of FYM i.e. 45 t/ha (table-1). These results were statistically significant. In the treatments FYM 15t/ha and 30 t/ha, sprouting were parallel upto 15t/ha day, later on F2 treatment showed increasing order in growth in comparison to F1; the same pattern was also observed in the case of F3. In the case of spacing treatment the results were in increasing order from S1, S2 and S3 (table-1), the results were statistically significant. In the case of vine length v/s spacing the increasing order was recorded from 0 to 43 days. The same pattern was recorded in case of different spacing used and the results were statistically significant (table-2).

Table 1: Growth parameters under different level of FYM and plant spacing in different interval of early growth period of *Dioscorea deltoidea*.

Treatment / FYM	Plant sprouted No. (0 days sprouting)	Plant sprouted No. (7days after sprouting)	Plant sprouted No. (15days after sprouting)	Plant sprouted No. (22days after sprouting)	Plant sprouted No. (29days after sprouting)	Plant sprouted No. (36days after sprouting)	Plant sprouted No. (43days after sprouting)
15 t/ha	11.56	23.44	33.00	52.22	54.44	56.67	58.11
30 t/ha	14.44	25.67	34.11	53.44	57.11	58.89	60.11
45 t/ha	16.44	28.56	37.33	55.67	58.78	60.56	62.56
CD (P=0.05)	1.95	2.92	4.74	3.35	2.24	2.33	3.04

Treatment / Spacing	Plant sprouted No. (0 days sprouting)	Plant sprouted No. (7 days after sprouting)	Plant sprouted No. (15days after sprouting)	Plant sprouted No. (22days after sprouting)	Plant sprouted No. (29days after sprouting)	Plant sprouted No. (36days after sprouting)	Plant sprouted No. (43days after sprouting)
25 x 25 cm^2	10.22	22.33	31.33	50.11	53.67	55.44	56.89
25 x 50 cm^2	14.56	26.44	34.44	54.33	57.00	59.11	60.67
50 x 50 cm^2	17.67	28.89	38.67	56.89	59.67	61.56	63.22
CD (P=0.05)	1.95	2.92	4.74	3.35	2.24	2.33	3.04

Table 2: Growth parameters under different level of FYM and plant spacing in different interval of early growth period of *Dioscorea deltoidea*.

Treatment / FYM	Plant length cm (0 days after sprouting)	Plant length cm (7 days after sprouting)	Plant length cm (15 days after sprouting)	Plant length cm (22 days after sprouting)	Plant length cm (29 days after sprouting)	Plant length cm (36 days after sprouting)	Plant length cm (43 days after sprouting)
15 t/ha	5.87	15.98	24.40	41.04	52.25	71.97	95.27
30 t/ha	6.40	16.53	25.09	41.79	52.89	72.54	95.86

45 t/ha	7.21	17.36	25.95	42.57	53.74	73.36	96.63
CD(P=0.05)	**1.52**	**1.62**	**1.38**	**1.50**	**1.75**	**1.50**	**1.66**
Treatment / **Spacing**	**Plant length cm (0 days after sproutin g)**	**Plant length cm (7days after sprouting)**	**Plant length cm (15 days after sprouting)**	**Plant length cm (22 days after sprouting)**	**Plant length cm (29 days after sprouting)**	**Plant length cm (36 days after sprouting)**	**Plant length cm (43 days after sprouting)**
25 x 25 cm^2	5.61	15.83	24.11	40.81	51.91	71.71	95.11
25 x 50 cm^2	6.51	16.73	25.19	41.68	52.78	72.61	96.01
50 x 50 cm^2	7.37	17.30	26.12	42.91	54.19	73.54	96.64
CD(P=0.05)	**1.52**	**1.62**	**1.38**	**1.50**	**1.75**	**1.50**	**1.66**

The number of sprouts and length of the creeper – treatment- wise were recorded from 0 to 43 days (table-1). The crop was harvested during December 2008, 2009 and 2010 in dormancy period. The maximum growth period and biomass was obtained during April to October. Of the three doses of FYM 15t/ha, 30t/ha and 45 t/ha applied in the month of December. The treatment of 45 t/ha produced maximum yield of fresh rhizomes i.e. 15.82, 38.76 and 59.72 t/ha after two, three and four years (table-3). In the terms of fresh weight, as the dose of FYM increases from lower to higher level, the rhizome yield were produced in increasing order, the results were statistically significant. In the same way the dry weight of rhizomes were also measured and diosgenin content was also extracted on dry weight basis in the chemistry lab.

Further it was observed that vegetative growth of crop was maximum in the months of July and August with too many tender shoots emerging up. Maximum growth was haphazard and spread around the supporting stakes. Due to unlimited and unidirectional higher growth in rainy season the parameters could not be recorded.

Table 3: Fresh weight of *D. deltoidea* rhizomes under different levels of FYM and plant spacing after 2nd, 3rd and 4th years and diosgenin content.

Treatment / **FYM**	**Fresh weight (T/ha) (2nd year)**	**Fresh weight (T/ha) (3rd year)**	**Fresh weight (T/ha) (4th year)**	**Diosgenin content in 10g (Dry Matter basis)**
15 t/ha	12.64	35.77	56.80	0.08
30 t/ha	14.28	37.24	58.28	0.08
45 t/ha	15.82	38.76	59.72	0.08
CD (P=0.05)	**1.23**	**2.21**	**1.18**	**NS**
Treatment	Fresh weight (T/ha)	Fresh weight (T/ha) (3rd	Fresh weight (T/ha) (4th	Diosgenin content in 10g (Dry Matter basis)

Spacing	(2nd year)	year)	year)	
25 x 25 cm^2	10.09	33.22	54.20	0.09
25 x 50 cm^2	14.19	37.01	58.02	0.08
50 x 50 cm^2	18.47	41.53	62.58	0.08
CD (P=0.05)	**1.23**	**2.21**	**1.18**	**NS**

4. Discussion

Field experiment was conducted for four years at institute's experimental farm, to develop economically valuable agro package for cultivation of *D. deltoidea* crop. All the treatments of different FYM application and various spacing showed significant influence on growth and overall fresh biomass of the crop. In terms of number of plant sprouts and their growth, all the treatments F1, F2 and F3 produced growth of vines (tillers) an increasing order from 0 to 43 days. In the same manner plant spacing also influenced number of sprouts. After 7th day, it was statistically significant. Different application of FYM and various spacing also influenced vine length upto 43 days. In literature survey there is no reference of any agro technology developed for *D. deltoidea* cultivation. Only two references are available for cultivation of *D. deltoidea* as inter cropping in forest plantation. During four years of experiment no irrigation was provided other than natural rain-fall. For crop growth, it was observed that 15 t/ha application of FYM is suitable. The similar observations were recorded in the case of vine length with different spacing. However, in the fresh rhizome weight the higher dose of FYM 45 t/ha was statistically significant and produced 15.82, 38.76 and 59.72 t/ha fresh rhizomes in 2nd , 3rd and 4th year. Wider spacing of 50 x 50 cm was also statistically significant and in closer spacing rhizomes yield was also statistically significantly (table-3). In the case of diosgenin content, it was statistically non significant.

Chauhan (1999) has suggested optimum harvest time from November to March, during the dormancy stage. We also followed the same time of planting as well as in harvesting practices. In literature, there are 2-3 references, regarding cultivation but they have taken 10 years to harvest under forest plantation. The fresh weight of yield (rhizomes), recorded was fivefold (Chauhan 1999; Gupta 1988; Anon 2000; Farooqi and Sreeramu, 2001).

Dioscorea deltoidea is in high demand globally in America, Africa and Asia. A great need and domestic demand in Nepal (Olsen and Larsen, 2003). Sher (2001) has listed *D. deltoidea* in high medicinal value nationally and internationally. Because, the *D. deltoidea* is a critically endangered species in India, Nepal, Bhutan and Pakistan and is not available in abundance, in its natural habitat and due to its illegal over exploitation, the high demand of this crop in near future can be met through proper cultivation practices for sustainable supply of material to the pharmaceutical industries.

5. Conclusion

Dioscorea deltoidea is an endangered species which has high medicinal importance. A field experiment was conducted to develop agro techniques. The effect of FYM 15, 30 and 45 t/ha by using three plant spacing (25 cm x 25 cm, 25 cm x 50 cm and 50 cm x 50 cm). After four years crop was harvested, It can be concluded that higher dose of FYM 45 t/ha and wider spacing 50 cm x 50 cm. was best for production of higher rhizome yield. In terms of diosgenin content on dry weight basis, it was 0.08 g., it was non significant.

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