Effect of fertilizer and irrigation on growth and yield of *Andrographis paniculata* (Burm.f.) Wall. Ex Nees var. *paniculata*

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Abstract

Andrographis paniculata (Burm.f.) Wall. ex Nees var. *paniculata* which belongs to the family Acanthaceae is an indigenous species in Sri Lanka. This study was designed to identify the effect of fertilizer and irrigation treatments on growth and yield of *A. paniculata*. The experiment was carried out in two agro ecological sites, the wet zone low country (WL1b) and the intermediate zone low country (IL2) of Sri Lanka. Factorial combination of three fertilizer treatments (no fertilizer, organic fertilizer only (1 kg per plot) and in-organic fertilizer only (N: P 80:40 kg /ha) and two irrigation methods (no irrigation and irrigation – twice a day) were used in a split plot experimental design. Growth characters measured showed significant variations between the two different sites. Highest growth was recorded in the wet zone with average dry weight per plant of 83 g compared to 53 g in dry zone. According to the dry matter production, the optimum time for the harvesting of plants were identified as 3.5 – 4 months after planting. Data analysis showed significant differences in the total, shoot and leaf dry weight per plant at different treatment levels. Root dry weights were not significantly different among treatment combinations. Results also revealed that the dry matter partitioning was significantly improved by the combined effect of both fertilizer and irrigation, but the magnitudes of impact are different for the two agroecological regions. Application of organic fertilizer with irrigation was found to be the most suitable combination for cultivation of *A. paniculata* in both zones.

Introduction

Andrographis paniculata (Burm.f.) Wall. ex Nees var. *paniculata* belongs to the family Acanthaceae is an indigenous species to India, Sri Lanka, Malay Peninsula, China, Indo-China and Thailand [1].The species found to be a weed in semi-shade areas in the moist and dry lowlands and moist mid-country areas in its native places in Sri Lanka. The entire plant is used in ayurvedic system in Sri Lanka and elsewhere. The plant is reported to posses bitter, astringent, anodyne, alexiphamic and tonic properties [2]. It is suggested to be useful in liver disorders, jaundice, dysentery, cholera, consumption, influenza and bronchitis [3]. The plant has been used against AIDS, cancer and a variety of bacterial and virally induced diseases. *A. paniculata* is used as a substitute for *Swertia chirata* Buch.-Ham. of the family Gentianaceae which is not found in Sri Lanka. In India, *Andrographis echioides* is used as an adulterant or substitute for *A. paniculata*. This plant is mostly cultivated in China and India [4].

A number of diterpenes from the aerial parts of *A. paniculata* have been isolated where the most important diterpenes are diterpene glycoside andrographolide and andropanoiside [5]. The leaves contain the maximum active principle content while in the stem it is in lesser amount.The presence of dehydroandrographolide succcinic acid mono ester, derived from andrographolide, and has been found to inhibit the human immunodeficiency virus (HIV) *in-vitro* [6]. The effect of agronomic practices used in cultivation of *A. paniculata* and its processing on chemical constituents has not been studied. According to the statistics available in year 2000 in Sri Lanka, the national demand for *A. paniculata* was estimated at about 12 mt/ year [7] and it has been locally collected from wild although it has been suggested that *A. paniculata* can be easily cultivated by seeds [8].

There is no information on the effect of agronomic practices used in cultivation of *A. paniculata* and its processing on its biomass and chemical constituents in Sri Lanka or elsewhere. Accordingly, the objective of this study was to investigate the effect of fertilizer and irrigation treatments on growth and yield of *A. paniculata*.

Materials and Methods

Seed collection and their germination

A. paniculata seeds were collected from the plants grown at the garden of Bandaranaike Memorial Ayurvedic Research Institute (BMARI), Nawinna. Only healthy plants were selected to collect seeds. Seeds were freshly collected from the dried pods and used for germination. Seeds were first soaked in water for 12 hrs and then placed in seed trays filled with sand. Seed trays were kept in a

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plant house under the shade and watered twice a day. The number of seeds germinated was counted and recorded at two-day intervals after the emergence of the first seedling approximately 7 days after sowing.

Selection of sites for trial, preparation of land and experimental design

Two sites were selected: Herbal garden at Ayurveda Hospital, Meegoda to represent wet zone low country (WL1b) with a mean annual rainfall of less than 2,800 mm/ year which contain red yellow podzolic soil (Site 1) and Herbal Garden at Girandurukotte to represent intermediate zone low country (IL2) with mean annual rain fall less than 1600 mm/ year which contain reddish brown earth soil (Site 2). Harrowing and ploughing of the land was done using a tractor. The land was leveled to prepare blocks and plots for planting. The area under the experiment was about 115.85 square meters and it was divided into 3 blocks of 7.8 × 3.9 m size. One block was divided into 18 plots of 1.2 × 1.2 m sizes which were arranged in two rows.

Factorial combination of three fertilizer treatments and two irrigation methods (Table 1) were as used and arranged in a split plot design where fertilizer treatments were replicated 6 times within a block and irrigation treatments were replicated 3 times.

Table 1: Fertilizer treatments and irrigation methods

Treatment	*Levels*
Fertilizer	1. No fertilizer
	2. Organic fertilizer only (1 kg/ plot) applied 1 week before planting
	3. In-organic fertilizer only (N:P 80:40 kg/ha) applied 1 week before planting
Irrigation (started only a month after establishment)	1. No irrigation
	2. Irrigation – Twice a day

Establishment of plants

Four centimetre tall plants were transferred into the small holes dug at 30 × 30cm distance within a plot. Daily watering was done twice a day for well establishment of plants in the field and after one month of growth, watering was done only for 9 plots within a block. *A. paniculata* was established in the two sites in two different seasons considering the rainfall pattern of the area. Plants were established at the end of March 2006 in Site 1 with the onset of inter monsoon before the southwest monsoon and mid September 2007 in Site 2 during inter monsoon before northwest monsoon.

Measurement of growth parameters

Growth was monitored during a 5 month period. First growth measurements were taken one week after the field establishment. It was repeated once a week for 2 months and once a month after 2 months over a total period of 5 months.

During this period plant height (cm), number of leaves, number of primary branches, days to 50% flowering, days to harvest, dry weight (g), leaf characters (leaf lamina length (cm)/ leaf lamina width (cm)/ petiole length (cm)/ petiole width (cm), leaf shape, leaf surface, days to maturity of the capsule, fruit characters (capsule length (cm)/ capsule width (cm) /no. of seeds per capsule), capsule shape, flower characters, pest and diseases were measured and recorded. Considerable variation was observed in the growth of plants from the beginning. Immediately after field establishment, the growth of *A. paniculata* seedlings was found to be very slow, which recovered later.

Soil analysis

Soil analysis was done before adding fertilizer to the soil. Twenty five soil samples each of 100 g was taken randomly from a depth of 5 cm uppermost soil layer into the polythene bags using small fork and spade. These samples were mixed separately to obtain single compound sample, crumbled the fresh samples by hand and spread it on aluminium trays. Trays were kept in an oven (40°C) for 3-4 days. The dried soil samples were sieved using 2 mm sieve. Nitrogen (N), phosphorus (P), potassium (K) content, pH, organic carbon and organic matter percentage were measured for each soil sample. This was done for two sites separately [9].

Results and Discussion

Site conditions

Soil analysis revealed that soil fertility status was different at the two sites. Soil pH of site 1 is acidic (5.64) compared to the value of site 2 (7.13). N content and percentage of organic carbon and organic matter in the site 1 is higher than that of site 2. P and K content recorded from the site 2 are higher than the site 1 (Table 2).

Seed germination

Seed germination was started 7 days after sowing and continued till 21 days. The seed germination rate of *A. paniculata* was high (90% ± 5.24) after 21 days. All seedlings that emerged from the germinated seeds were healthy and after they reached 4 cm in height they were transferred to the field, with three different fertilizer treatments.

Growth and yield

These plants particularly in the two sites were morphologically different (Tables 2 and 3). These morphological differences mainly appeared due to the differences in the soil type, temperature and the rainfall

pattern of the two sites. Plants grown at Site 1 contained dark green fleshy leaves with broadly ovate-lanceolate shape compared to the pale green coriaceous leaves of ovate-lanceolate observed in Site 2.

The differences in growth of plant parts seem to be the combined effect of both fertilizer and irrigation.

The results also showed that height and number of leaves varied widely among the different fertilizer treatments and higher results were recorded from Site 2 compared to the Site 1 (Tables 5 and 6). Plants grown under irrigation with the application of organic fertilizer gave higher yields in both sites.

Table 2: Soil pH, N, P, K content and organic carbon (OC) and organic matter (OM) recorded from two sites

Site	*pH*	*N mg/g*	*P mg/g*	*K mg/100g*	*OC%*	*OM%*
Meegoda (Site 1)	5.64 ±0.27	1.79 ±0.21	25.17 ±5.38	0.24 ±0.02	1.98 ±0.25	3.41 ±0.44
Girandurukotte (Site 2)	7.13 ±0.47	1.12 ±0.21	36.34 ±6.21	13.10 ±2.84	0.75 ±0.24	1.29 ±0.31

Table 3: Mean of leaf length, leaf width, petiole length and petiole width of *Andrographis paniculata* under different treatments on final harvest at the herbal garden at Ayurveda Hospital, Meegoda

Treatment		*Leaf length (cm)*	*Leaf width (cm)*	*Petiole Length (cm)*	*Petiole Width(cm)*
Inorganic	Irrigated	11.33±0.614	3.64±0.231	4.15±0.583	2.024±0.194
	Non irrigated	10.16±0.809	3.09±0.178	3.30±0.307	2.05±0.20
Organic	Irrigated	10.75±0.897	3.22±0.273	4.06±0.520	2.125±0.263
	Non irrigated	10.71±0.556	2.6±0.263	3.3±0.280	1.96±0.187
Control	Irrigated	10.04±0.503	2.86±0.209	3.04±0.307	2.0±0.20
	Non irrigated	9.64±0.547	2.69±0.204	3.28±0.344	1.93±0.43

Table 4: Mean of leaf length, leaf width, petiole length and petiole width of *Andrographis paniculata* under different treatments on final harvest at the herbal garden, Girandurukotte.

Treatment		*Leaf length (cm)*	*Leaf width (cm)*	*Petiole Length (cm)*	*Petiole width(cm)*
Inorganic	Irrigated	9.84±1.045	2.76±0.204	4.25 ±1.181	1.85±0.30
	Non irrigated	9.57±1.384	2.56±0.462	4.67±1.423	1.6±0.469
Organic	Irrigated	9.90±1.628	2.75±0.453	4.13±0.585	1.85±0.191
	Non irrigated	7.58±0.371	1.9±0.324	3.18±0.147	1.25±0.262
Control	Irrigated	9.47±1.263	4.09±0.205	4.38±0.784	1.85±0.208
	Non irrigated	8.83±0.479	2.35±0.172	4.23±0.806	1.58±0.434

Table 5: Mean height, mean number of primary branches and mean no. of leaves of *A.paniculata* at final harvesting stage under different treatments at the herbal garden, Meegoda

Treatment		*Height (cm)*	*No. primary branches*	*No. of leaves*
Inorganic	Irrigated	47.88±3.88	54±2.88	297±26.62
	Non irrigated	47.89±2.96	38±1.87	222±22.01
Organic	Irrigated	60.08±3.60	79±2.26	423±29.94
	Non irrigated	56.95±2.64	37±1.50	345±25.36
Control	Irrigated	46.98±3.44	57±1.72	231±24.90
	Non irrigated	46.31±2.97	36±1.37	196±20.66

Table 6: Mean height, mean number of primary branches and mean no. of leaves of *A.paniculata* at final harvesting stage under different treatments at the herbal garden, Girandurukotte

Treatment		*Height (cm)*	*No. primary branches*	*No. of leaves*
Inorganic	Irrigated	61±3.755	24±2.06	949±63.10
	Non irrigated	61.25±2.217	19±2.98	763±49.92
Organic	Irrigated	64.75±3.795	22±1.74	905±57.8
	Non irrigated	59.25±2.872	21±1.20	827±41.37
Control	Irrigated	59±2.449	24±0.5	726±45.69
	Non irrigated	56.75±2.722	19±0.93	867±33.70

Table 7: Mean leaf area (LW), dry weight of partition to leaves (DWL), shoot (DWS), root (DWR), total dry weight (TDW) of plant at final harvesting under different treatments at the herbal garden, Meegoda

Treatment		*LA*	*DWL*	*DWS*	*DWR*	*TDW*
Inorganic	I	5506.67 ±866.87	27.34 ±2.17	40.1 ±3.28	2.92 ±0.21	70.36 ±5.14
	NI	4517.5 ±307.97	18.70 ±0.66	27.92 ±1.90	2.56 ±0.29	49.18 ±2.24
Organic	I	5656.67 ±1172.37	31.65 ±2.37	48.54 ±5.18	3.18 ±0.30	83.37 ±7.13
	NI	5001.67 ±291.19	21.56 ±2.29	41.84 ±7.46	2.88 ±0.35	66.28 ±9.72
Control	I	3087.17 ±295.82	12.48 ±1.16	19.12 ±2.63	1.21 ±0.19	32.8 ±3.43
	NI	3064.17 ±406.17	14.37 ±1.01	21.13 ±1.32	1.57 ±0.30	37.07 ±2.35

Table 8: Mean leaf area (LA), dry weight of partition to leaves (DWL), shoot (DWS), root (DWR), total dry weight (TDW) of plant at final harvesting under different treatments at the herbal garden, Girandurukotte

Treatment		*LA*	*DWL*	*DWS*	*DWR*	*TDW*
Inorganic	I	4272.5	19.57	30.75	3.29	53.6
		±701.62	±2.70	±11.13	±0.48	±13.56
	NI	3195	17.48	36.55	3.42	57.44
		±355.65	±2.53	±4.90	±0.71	±7.61
Organic	I	3840	15.04	35.09	3.33	53.46
		±321.64	±0.62	±6.70	±0.27	±7.24
	NI	3042.5	17.33	29.72	2.29	49.33
		±362.57	±1.98	±4.34	±0.34	±5.69
Control	I	2997.5	13.5	30.11	3.20	46.81
		±668.44	±2.6	±10.39	±0.94	±13.51
	NI	2840	14.19	23.88	3.02	41.09
		±409.16	±1.62	±4.02	±0.21	±5.11

Organic and inorganic fertilizer at the rate applied here was sufficient for good growth. Use of organic fertilizer was only possible at the planting stage. Subsequent application of two types of fertilizers was not needed comparing the harvesting time and growth. However, the two types of fertilizer produced plants with different compositions of plant parts. Higher root yield at site 2 (herbal garden at Girandurukotte) was also due to the better soil conditions (Tables 7 and 8).

Although studying the effect of fertilizer and the irrigation on increasing the dry matter yield was the intension of this experiment and the changes in the composition of plant parts could be an important consideration.

Greater yield of leaves was important in this crop and methods of improving shoot growth with more branches were the main concern. The data showed that when the application of organic fertilizer with irrigation dry matter yield of all parts and leaf area were greater mainly in the Site 1.

The overall leaves, shoot and root dry matter yield in all experimental plots was high compared to control. A higher per plant yield was obtained from the plants grown under organic fertilizer with irrigation (Tables 7 and 8). Yield from the site 2 was poor when compared to the harvest obtained from site 1 where the initial nitrogen level was high (Table 3).

Use of fertilizer was very important for the successful growth of these plants. Higher yields per plant could be obtained by using fertilizer. Response to fertilizer was clear from the seedlings stage on wards. Both organic fertilizer and inorganic fertilizer were effective in improving the growth. Application of organic fertilizer before planting and inorganic fertilizer used here showed a continuous increase in growth in height during the 4-5 months of study and gave the highest dry matter yield. Using organic fertilizer must have had its physical advantages too. Better yields also can be expected by using higher levels of organic fertilizer without using inorganic fertilizer which is not recommended for medicinal plant cultivations. Although the plants in the irrigated blocks produced higher dry matter yields when compared to non-irrigated.

Harvesting time

Harvesting at the proper time in medicinal plants is very important. When plants started flowering after 3 1/2 months of growth they continually produced flowers and fruits. The percentage composition of plant parts also changes with the age of plants. It was noted that when plants are not harvested at correct time plants having flowers with more fruits and most of leaves started to yellow. The best harvesting time for *A.paniculata* is at the flowering stage. Harvesting at an earlier stage of 2 months yielded plants with a balanced composition of plant parts but with low dry matter yield. Older plants (5 months) mostly contained flowers and capsules compared to 4 months old plants with more leaves with flowers. It was very clear that when the plants were kept for a longer period they reached senescence with more capsules.

Therefore, it seems that harvesting at 4 months of growth is more acceptable when 4 cm seedlings were the

planting materials. At this stage the entire plant can be uprooted and air dried. The observations in these experiments showed that 3 1/2 – 4 months old plants were of the best quality (visually) with good proportions of leaves, shoots and flowers.

Pests and diseases

During the study period no pests or diseases were observed at any stage. Plants started to die with maturity of fruits at the age of 5-6 months in the field.

Conclusions

Experiments carried out to study the effect of irrigation and inorganic and organic fertilizer on the growth of plants raised from seeds revealed that organic fertilizer had significant effects on the plant growth. Inorganic fertilizer at the rate applied also gave good growth. The plants were harvested by up rooting at the end of 3 1/2 – 4 months of growth under organic fertilizer with an average yield of 9,500 kg and 6,000 kg /ha at Site 1 and 2, respectively.

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