EUROPEAN ACADEMIC RESEARCH
Vol. III, Issue 2/ May 2015

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

# Effect of Fertilizers on the Root Yield of *Rauvolfia serpentine*

Dr. SALIL DHAWAN
Course Coordinator (Forestry)
Forest Research Institute University, Dehradun, India

**Abstract:**

*Several hundred genera are used in herbal remedies and in traditional or folklore medicines throughout the world. They are used in the form of crude drugs, which are dried parts of the medicinal plants (root, stem, wood, bark, leaves, flowers, fruits, seeds and in some cases whole plants) or their extracts. Chemically, depending upon their established principles, plants may have alkaloids, glycosides, steroids or other groups of compounds, which may have marked pharmaceutical actions as anticancerous, antimalarial, antihelminthic or antidysentric, etc. Among the numerous medicinal plants growing in our forests, the one that has attracted considerable attention and come to the lime light in recent years is Rauvolfia serpentina Benth commonly known as 'Sarpgandha' is one of endangered medicinal species extensively used in treatment of high blood pressure, epileptic fits, snake bite etc. The most useful part of this plant is its roots, which has medicinal value. Fertilizers are reported to influence plant growth and yield. The present paper highlights the influence of various combinations of fertilizers on root yield of* ***Rauvolfia serpentina.***

**Key words:** *Rauvolfia serpentina;* Fertilizers; Root yield; Medicinal plants; NPK.

According to the World Health Organization (WHO), 80 percent of the population in developing countries relies on traditional medicine, mostly in the form of plant drugs for their health care

needs. India has a unique position in the world where a number of traditional systems of medicine are practiced such as Ayurveda, Siddha, Unani, Homeopathy, Yoga and Naturopathy for the total health care. These systems of medicine are heavily dependent upon the medicinal plants. Additionally, modern medicines contain plant derivatives to the extent of about 25 percent. Over 1.5 million practitioners of the Indian system of medicine in the oral and codified streams use medicinal plants in preventive, promotional and curative applications. It is estimated that there are over 7800 medicinal drug manufacturing units in India, which consume about 2000 tones of herbs annually (Singh, 2001).

Currently more than 75 percent of the herbal requirement is met through wild collections. While the demand for medicinal plants is increasing, their survival in their natural habitat is under growing threat. Among the numerous medicinal plants growing in our forests, the one that has attracted considerable attention and come to the lime light in recent years is *Rauvolfia serpentina* Benth Ex Kurz belonging to Apocyanaceae family known from very ancient days. *R. serpentine,* commonly known as 'Sarpgandha' is one of such endangered medicinal species extensively used in treatment of high blood pressure, epileptic fits, snake bite etc. The roots of this plant have been used in India from ancient times. A few drugs have attracted much worldwide attention as the root of R. serpentine has. This is due to its efficacy in reducing high blood pressure and also to its well-marked sedative properties. Extracts of the roots are valued for the treatment of intestinal disorders, particularly diarrhoea and also as anthelmintic. Some reports have tried to link breast cancer with *Rauwolfia* derivatives. The collectors of crude drugs have ruthlessly extracted the plant without any consideration for its regeneration, which resulted in its extermination in certain areas. To meet the internal and international demands, it has now become imperative to produce quality raw materials in significant quantities. This can only be achieved by promoting

domestication and cultivation of medicinal plants, which have internal demand in large quantity and have export and import potential.

Though, *R. serpentina* can be propagated by various methods, optimum yield of roots (including thick, thin and fibrous) is obtained, when propagation is done by seeds. The yield of roots is highest in the plants raised through seeds as compared to the plants raised by vegetative propagation (Badhwar *et. al.*, 1956). Under forestry conditions, a plant yield 14.88 gm roots, whereas under irrigated agricultural conditions the plant yields 45.5 gm (40.3 gm thick and 5.1 gm of fibrous) roots in two years (Badhwar *et. al.,* 1955a).

Yield of roots vary abnormally, from ¼ lb to 8 or 9 lb. of green roots per plant (Nair, 1955). The higher yield is obtained from older plants (Sobti *et. al.,* 1959) the root yield in three years is more than the plants of two years (Govil *et. al.,* 2002). There is significant increase in the yield of roots with the age of plant and 2-3 yrs old plants are suitable for better harvesting of roots (Mathur and Singh, 1965). Rao *et. al.* (1999) suggested that the plants should be harvested after two years, whereas, some authors have recommended the harvesting of the species after 15 months which is most economical also (Sarin, 1982). Jaryal (2004) noted that the plant becomes mature at the age of 18 months and about 8-9 quintal of roots per acre can be obtained in this period. Anon (1997b) reported that heavy root is obtained, when *R. serpentina* is raised as a pure crop, the growing of intercrops gives larger overall profit. Anon (2004) found that an area of one hectare can produce 2,000 kg of dry roots. Sharma (2005a) reported that the species "RS-1" developed by Jawaher Lal Nehru Agricultural University, Jabalpur (M.P) yield 10 quintal of dried roots per acre in 18 months.

Fertilizers are known to increase the growth of plants. Literature pertaining to use of fertilizers on medicinal plants is very limited and scattered. Some information is available on the response of fertilizers application on the growth of few

medicinal plants. Therefore, an experiment was conducted in the Central Nursery of Forest Research Institute, Dehradun with an objective to study the Influence of various combinations of fertilizers on root yield of the plant.

## Methodology

The experimental site was in the F.R.I. campus. The field selected was 40 m long and 16 m wide having 2.5 m to 3.5 m high lantana bushes, which were uprooted for clearing. The tractor hoed the whole field carefully leveling an area of 30 m X 13 m. Forty-eight plots of equal size were prepared for the experiment according to the plan in the area of 311.91 $m^2$.

Before sowing of seedlings, soil samples of the experimental plot were taken randomly from different parts of the field. These were collected from 0 to 30 cm depth and analyzed for its physical and chemical properties. The physical analysis of the soil of the experimental area was conducted by the method given by Piper (1966). The chemical analysis of the soil was conducted to find out the percentage of Organic Carbon and Organic Matter by using Walkey and Black method (1934). The available N, P and K was find out by using Alkaline permanganate method (Subbiah and Asija, 1956), Olsen's method (Olsen, 1954) and Flame photometer method respectively.

Sixteen treatments (T to T15) of fertilizers consisting various combinations (table-1) were selected for the experiment including the control (T). Three replications of each treatment were carried out. The doses selected for FYM, N, P and K were 25 t/ha, 60 kg, 30 kg, 30 kg per hectare respectively (Anon, 1998; Rao *et. al.*, 1999; Chandra and Pandey, 2004).

**Table -1: Showing Combinations of Fertilizers**

| Treatment | Fertilizers | Quantity /ha |
|---|---|---|
| T | **Control** | - |
| T 1 | FYM | *25 ton* |
| T 2 | FN | 25 ton, 60 kg |

| | | |
|---|---|---|
| T 3 | FP | 25 ton, 30 kg |
| T 4 | FK | 25 ton, 30 kg |
| T 5 | FNP | 25 ton, 60 kg, 30kg |
| T 6 | FNK | 25 ton, 60 kg, 30kg |
| T 7 | FPK | 25 ton, 30 kg, 30kg |
| T 8 | FNPK | 25 ton, 60 kg, 30kg, 30kg |
| T 9 | N | 60 kg |
| T10 | P | 30 kg |
| T11 | K | 30 kg |
| T12 | NP | 60 kg, 30 kg |
| T13 | NK | 60 kg, 30 kg |
| T14 | NPK | 60 kg, 30 kg, 30 kg |
| T15 | PK | 30 kg, 30 kg |

The experimental area (30 m X 13 m) was ploughed mechanically quite deep. The weeds were removed and an area measuring 28.1 m X 11.1 m was prepared for the transplantation of seedlings. 48 equal plots of 2.40m x 1.80 m size were prepared. According to the plan, different combinations of fertilizers were applied (table-1) in these plots.

**Table -2: Quantity of Fertilizers Applied**

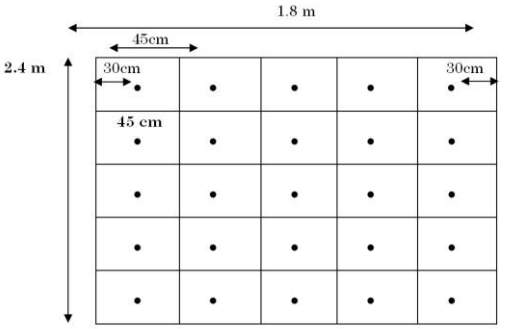
| **Fertilizer** | **Element** | **Available %** | **Quantity/ha** |
|---|---|---|---|
| Urea | N | 46 | 130 kg |
| Single Super Phosphate | $P_2O_5$ | 16 | 187.50 kg |
| Muriate of Potash | $K_2O$ | 60 | 50 kg |

Table –2 shows the quantity of fertilizers N, P and K applied in the plot per hectare. Judicious use of fertilizers includes proper choice and dosage of fertilizers as well as appropriate time and method of their application. Nutrient requirement of crop differ significantly during different growth stages. Plants absorb nitrogen throughout their growth period whereas phosphate is absorbed at a faster rate during early growth period because it helps in growth and development of roots. Similarly, is the case with potash, however, it helps in translocation of plant nutrients, water and photosynthesis within plant the body throughout active growth. Fertilizer, nitrogen is highly mobile and may be lost through volatilization and leaching, if not utilized by the plants. Therefore, it was applied in split doses

during the period of plant growth. Potassium and phosphorus are less mobile in comparison to nitrogen, so the entire quantity was applied at the time of transplantation (basal dose). 30 kg of nitrogen per hectare was applied as basal dose and 30 kg per hectare after 50 days of transplantation. 30 kg of phosphorous and 30 kg of potassium per hectare were applied as basal dose before transplantation. Well rotten FYM at the rate of 25 tons per hectare was applied as basal dose in the plots before transplantation.

A distance of 0.50m was kept between two plots. Rows of slightly raised mounds (merh) were for transplantation made in every plot. Row-to-row distance was kept 45 cm and plant-to-plant distance in a row was 30 cm. Healthy seedlings (1200 no.) from root trainers were selected for transplantation according to the plan in the 48 prepared plots. 25 seedlings were transplanted in each plot, as 3 replications of each treatment were to be carried out therefore, 75 seedlings (25x3) of each treatment were transplanted (fig.-1). The plots were observed and maintained regularly. The field was kept relatively weed-free during the period of growth. Four weedings along with soil working were carried out in the months of October 03, February 04, July 04 and October 04. A contact insecticide Cypermethrin (0.02%) and fungicide Radomil were sprayed on leaves in August 03 and 04 to protect the plants from various diseases and pests. The crop duration was from March 03 to January 05.

**Pattern of Seedlings Transplantation in a Plot**



## Excavation of Roots

The plants were excavated in January 05 after 19 months from transplanting. The plants were excavated after rainfall, when the temperature was lowest. The soil around the plant was loosened carefully with the help of spade and pointed khurpi to prevent the roots from any kind of damage (fig.–2&3). After digging, the plants were excavated with roots. The roots along with the plant were cleaned and immersed in water for washing the attached soil. These were also washed gently with the help of brush for removing any small bit of soil (fig.-4) and kept for drying in shade.

**Tables-3: Details of Layout**

| Sl. No. | Description | Plan |
|---|---|---|
| 1. | Design | Randomized Block Design (Factorial) |
| 2. | Replication | Three |
| 3. | No. of Treatments | 16 |
| 4. | Total No. of plots | 48 |
| 5. | Gross field size | 40 m x 16m |
| 6. | Net experimental area | 28.1 m X 11.1 m |
| 7. | Distance between replications | 1 m |
| 8. | Distance between plots | 0.50 m |
| 9. | Size of a single plot | 2.40 m x 1.80 m |
| 10. | No. of Rows in a plot | 5 |
| 11. | Distance between rows | 0.45 m |
| 12. | Plant to plant distance in a row | 30 cm |
| 13. | No. of plants per plot | 25 |

**Table -4: Details of Cultural Operations with Time**

| Sl. No. | Operations (Feb 03 to Jan. 2005) | Time |
|---|---|---|
| 1. | Cleaning of plot | Feb 03 |
| 2. | Preparation of potting media | March 03 |
| 3. | Sowing of seeds | 21st March 03 |
| 4. | First germination of seeds | 19th April 03 |
| 5. | Date of complete germination | 28th may 03 |
| 6. | Ploughing of field mechanically | June 03 |
| 7. | Preparation of experimental plots | June 03 |
| 8. | Transplantation of seedlings | July 03 |
| 9. | Watering of plots | When required |
| 10. | Weeding and soil working | Oct. 03, Feb. 04, July 04 & Oct. 04 |
| 11. | Application of fertilizers | July 03, Sept. 03 and July 04 |
| 12. | Data collected | July 03, Oct. 03, Jan. 04, April 04, July 04 and Oct. 04 & Jan. 05. |
| 13. | Spray of insecticides | Aug. 03 and 04 |
| 14. | Spray of fungicides | Aug. 04 |
| 15. | Excavation of roots | 27th & 28th Jan. 05 |
| 16. | Crop duration | March 2003 to Jan. 2005 |

Table-4 shows the details of cultural operation during the experiment. Seeds were sown on 21st March 03, seedlings were transplanted in July 03 and roots were excavated on 27th and 28th Jan. 05. Germination started on 19th April 03 and completed on 28th May 03. Four weeding (Fig. 5) were done with soil working. Fertilizers were applied in July and Sept. 03. Insecticides and fungicides were sprayed in Aug. 04.

## Data Collection

To see the effect of fertilizers on root yield, total fresh root weight, number of root branches and maximum root diameter, were noted after excavation. After recording these, the roots were separated and the roots of more than 0.04 mm diameter were taken for fresh and dry root weights, total root length and root volume.

1. **Total fresh root weight** (gm): The fresh roots of the 5 selected plants including fibrous roots were weighed after washing and drying and were recorded as total fresh weight. (fig.-6 to 9)
2. **Fresh root weight** (gm)**:** Weight of fresh roots excluding fibrous roots (root less than diameter of 0.04 mm) was considered as fresh weight of roots i.e. roots more than 0.04 mm diameter were weighed.
3. **Dry roots weight** (gm): Roots (more than diameter of 0.04 mm) were air dried for 3-4 months in shade and subsequent weights were taken up till constant weight was obtained. Therefore, constant weight of dried roots excluding fibrous roots was considered as dry root weight.
4. **Number of root branches:** The average number of root branches (big or small) on the main root was recorded as total number of root branches. The main root was also included.
5. **Maximum root diameter (mm):** The maximum diameter of the thickest root was measured by digital Vernier caliper (in mm) and was recorded as maximum root diameter.
6. **Total root length (cm):** The branches of the root bunch were separated carefully and their lengths were measured separately. The total length of all root branches (more than 0.04 mm) was recorded as total root length.

7. **Root volume (cc):** Roots excluding fibrous roots were taken for the calculation of root volume. The volume of the roots (more than 0.04 mm) was calculated by water displacement method by using measuring cylinders and recorded as root volume.

The collected data was analyzed and interpreted on the basis of descriptive and inferential statistics. Mean and S.E. were calculated and Anova was used to see the level of significance for the differences obtained in growth, root yield and total alkaloids of the plant. To study the relationship between various variables, correlations were applied.

## Result and Discussion

**Table-5: Physical Analysis of Soil**

| Sl. No. | Soil Component | Content (%) | Method of determination |
|---|---|---|---|
| 1. | Sand | 45 | Piper (1966) |
| 2. | Silt | 25 | |
| 3. | Clay | 30 | |

The results of soil description are presented in table-5. The soil of the experimental area was analyzed by the method given by Piper (1966). The soil of the area was found silty clayey loam with 45 % of sand, 25 % of silt and 30 % of clay.

**Table-6: Chemical Analysis of the Soil**

| Sl. No. | Soil Component | Value | | Method of determination |
|---|---|---|---|---|
| | | % | Per Ha | |
| 1. | Organic Carbon | 1.04 | | Walkey and Black method (1934) |
| 2. | Organic Matter | 1.79 | | |
| 3. | pH | 7.0 | | |
| 4. | Available N | 0.023 | 515 kg | Alkaline permanganate method |

| | | | | |
|---|---|---|---|---|
| | | | | (Subbiah and Asija, 1956) |
| 5. | Available P | 0.004 | 89 kg | Olsen's method (Olsen, 1954) |
| 6. | Available K | 0.007 | 156 kg | Flame photometer method |

Table –6 presents the chemical analysis of the soil of experimental area. The pH of the soil was 7.0 by soil: water suspension. Organic carbon and organic matter in the soil were found to be 1.04 % and 1.79 % respectively. The percentage of N, P and K was obtained 0.023 %, 0.004 % and 0.007 % respectively or 515 kg, 89 kg and 156 kg per hectare in the same order. According to Gupta (2003), the quantity of P was high and N as well as K was medium in the soil.

**Table -7: Availability of NPK in different combinations**

| Treatments | N (kg /ha) | P (kg/ha) | K (kg/ha) |
|---|---|---|---|
| T | 515.2 | 89.6 | 156.8 |
| T 1 | 555.2 | 109.6 | 236.8 |
| T 2 | 615.2 | 109.6 | 236.8 |
| T 3 | 555.2 | 139.6 | 236.8 |
| T 4 | 555.2 | 109.6 | 266.8 |
| T 5 | 615.2 | 139.6 | 236.8 |
| T 6 | 615.2 | 109.6 | 266.8 |
| T 7 | 555.2 | 139.6 | 266.8 |
| T 8 | 615.2 | 139.6 | 266.8 |
| T 9 | 575.2 | 89.6 | 156.8 |
| T10 | 515.2 | 119.6 | 156.8 |
| T11 | 515.2 | 89.6 | 186.8 |
| T12 | 575.2 | 119.6 | 156.8 |
| T13 | 575.2 | 89.6 | 186.8 |
| T14 | 575.2 | 119.6 | 186.8 |
| T15 | 515.2 | 119.6 | 186.8 |

Table – 7 shows total available quantity of N, P, and K per hectare to the plant through different treatments including the calculated value (table – 6) of available N, P and K kg/ha in the soil. The quantity of N, P and K available to the plants in 25 t/ha of FYM are 40 kg, 20 kg and 80 kg respectively (Cooke, 1972).

## Climate

The Doon valley lies between latitude 30 to 33°32′ N and longitude 77° 43′ to 73° 24′ E. It is an open valley enclosed by Shiwalik hills in the South, upper Himalayas in the North, Yamuna River on the West and Ganga on the East (Srivastava and Kumar, 2003). The valley is protected from the extremes of climate. The meteorological data viz. maximum and minimum temperature, relative humidity in the morning and in the evening, rain fall, bright sunshine hours and wind velocity were recorded during the crop growth during the years 2003 and 2005 and are depicted in fig 10 to 12.

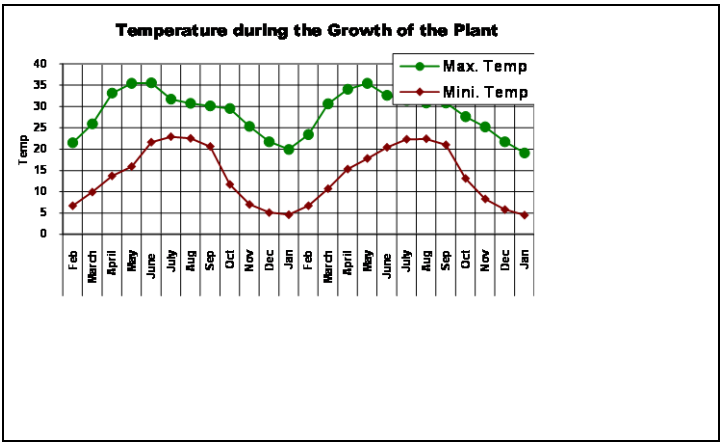



**Fig.-10: Temperature during the Growth of the Plant**

Fig.10 depicts that temperature was maximum in the months of May and June and was minimum in the month of January in both the years.

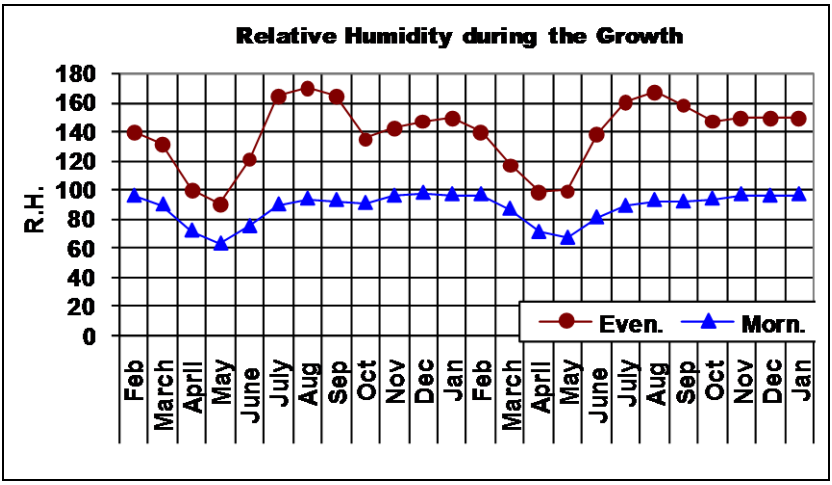



**Fig.-11: Relative Humidity during the Growth of the Plant**

The relative humidity recorded in the morning and in the evening during the growth period of the plant is shown in fig.-11. Maximum humidity was recorded in the month of August and minimum in the month of May. Relative humidity in the morning ranged from 63 to 98 and in the evening from 27 to 76 percent respectively.

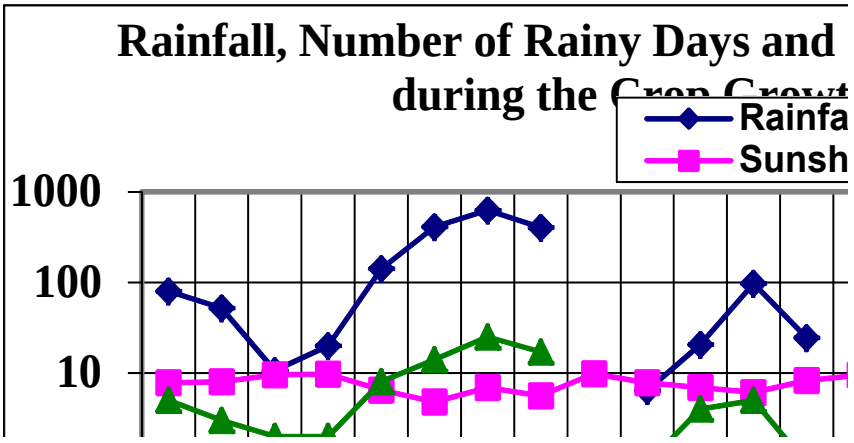



**Fig.-12: Rainfall, Rainy Days and Sunshine hours during the Growth of the Plant**

Fig -12 presents that maximum rainfall occurred in the month of August followed by July and September in the year 03. In the year 04, maximum rainfall has recorded in July followed by

August. Bright sunshine hours were recorded more in the months of April, May and September in the year 2003, March and May in the year 2004. Number of rainy days was maximum in the months of August 03 and July and August 04 whereas minimum rainy days were recorded in the months of November, February and December in the years 03 and 04.

## Effect of fertilizers on Root Yield

The root yield is a fraction of total fresh weight of the roots, fresh weight of roots (roots > 0.04 mm), dry weight of roots, number of root branches, maximum diameter, root volume and total length of the roots (roots > 0.04 mm).

## Effect of Fertilizers on Total Fresh Root Weight

**Table-8: Total Fresh Root Weight in different Treatments**

| Treatment | Root Weight (Mean) in gm |
|---|---|
| T | 84.26 |
| T 1 | 58.62 |
| T 2 | 61.08 |
| T 3 | 94.69 |
| T 4 | 72.03 |
| T 5 | 53.01 |
| T 6 | 56.74 |
| T 7 | 60.21 |
| T 8 | 63.13 |
| T 9 | 88.75 |
| T10 | 89.95 |
| T11 | 61.69 |
| T12 | 87.25 |
| T13 | 78.66 |
| T14 | 64.01 |
| T15 | 79.51 |

**Table-9: Analysis of variance of fertilizers on total fresh root weight**

| Source | df | SS | MS | F |
|---|---|---|---|---|
| **Treatment** | 15 | 8475.21 | 565.01* | 2.35 |
| **Replication** | 2 | 1497.07 | 748.54 | 3.11 |
| **Error** | 30 | 7222.40 | 240.75 | |
| CD (0.05) | 24.83 | | | |

| * Significant at 0.05 |
|---|

Table-8 and 9 present the influence of various combinations of fertilizers on the total fresh root weight of the plants under different treatments. It varied with the application of different combinations of fertilizers and ranged from 53.01 gm to 94.69 gm, maximum recorded in the treatment T3 followed by T10 (89.95 gm) and T9 (88.75 gm), whereas minimum 53.01 gm was obtained in T5. The total fresh root weight of control was found to be 84.26 gm. The F and CD values were found to be 2.35 and 24.83 respectively. The analysis of the data shows that significant loss in the total fresh root weights were recorded in the plants under treatments T1, T5, T6 and T14. The result obtained is significant at 5%.

## Fresh Weight of Roots (roots > 0.04 mm)

**Table-10: Mean Value of Fresh Root Weight under different Treatments (roots > 0.04 mm)**

| Treatment | Fresh Root Wt. (Mean) in gm |
|---|---|
| T | 83.06 |
| T 1 | 54.93 |
| T 2 | 58.06 |
| T 3 | 88.7 |
| T 4 | 67.89 |
| T 5 | 52.31 |
| T 6 | 51.68 |
| T 7 | 56.63 |
| T 8 | 60.84 |
| T 9 | 82.03 |
| T10 | 81.71 |
| T11 | 56.41 |
| T12 | 80.46 |
| T13 | 71.79 |
| T14 | 58.4 |
| T15 | 73.47 |

**Table-11: Analysis of variance of different fertilizers on fresh root weight**

| Source | df | SS | MS | F |
|---|---|---|---|---|
| **Treatment** | 15 | 7267.93 | 484.53** | 2.41 |
| **Replication** | 2 | 1445.65 | 722.89 | 3.6 |
| **Error** | 30 | 6026.45 | 200.88 | |
| CD (0.05) | 22.68 | | | |
| CD (0.01) | 29.86 | | | |
| ** Significant at 0.01 | | | | |

The results obtained regarding the influence of different treatments on the fresh root weight are presented in table-10 and 11. It varies from 51.68 gm to 88.7 gm, maximum recorded in the treatment T3 followed by control (84.26 gm) and T9 (82.03 gm) and minimum (51.68 gm) obtained in T6.

The F and CD values were found to be 2.41 and 22.68 at 5 % and 29.86 at 1 % respectively. From the analysis, it is predicted that different fertilizers influence the fresh root weight of the plant, as significant differences in the fresh root weights of the plant under different treatments were recorded. There was significant loss of weight with control in the treatments T1, T2, T5, T6, T7, T11 and T14 at the level of 0.05 and in the plants under treatment T5 and T6 at 1%. The mean values were observed 54.93 gm, 58.06 gm, 53.01 gm, 51.68gm, 56.63 gm, 56.41 gm and 58.4 gm in the same order.

## Dry Root Weight

**Table-12: Mean Value of Dry Root Weight under different Treatments**

| Treatment | Dry Root Weight (Mean) in gm |
|---|---|
| T | 43.23 |
| T 1 | 37.6 |
| T 2 | 38.61 |
| T 3 | 53.77 |
| T 4 | 39.59 |
| T 5 | 29.63 |
| T 6 | 27.75 |
| T 7 | 31.61 |
| T 8 | 36.98 |

| | |
|---|---|
| T 9 | 45.99 |
| T10 | 46.37 |
| T11 | 35.22 |
| T12 | 46.58 |
| T13 | 44.8 |
| T14 | 37.46 |
| T15 | 42.05 |

**Table-13: Analysis of variance of different fertilizers on dry root weight**

| **Source** | **df** | **SS** | **MS** | **F** |
|---|---|---|---|---|
| **Treatment** | 15 | 2162.47 | 144.16* | 2.00 |
| **Replication** | 2 | 407.33 | 203.67 | 2.83 |
| **Error** | 30 | 2159.07 | 71.97 | |
| CD (0.05) | 13.58 | | | |
| * Significant at 0.05 | | | | |

Table-12 and 13 depict the result obtained regarding the effect of different fertilizers on dry root weight of the plant which ranged from 27.75 gm to 53.77 gm. recorded in the treatment T3 followed by T12 and T10 (46.58 gm and 46.37 gm respectively). Minimum recorded in T6 (27.75 gm).

The CD value was found to be 13.58 and the F value was calculated as 2.00. This shows that there were significant differences in the dry root weights of the plants under various treatments. Significant decrease was noted in the weight of the plants under treatment T6 (27.75 gm) with the control. The result found is significant at the level of 0.05.

## Root Length

**Table-14: Analysis of variance of different fertilizers on total root length**

| **Source** | **df** | **SS** | **MS** | **F** |
|---|---|---|---|---|
| **Treatment** | 15 | 20304.58 | 1353.65***** | 2.27 |
| **Replication** | 2 | 4484.58 | 2242.29 | 3.76 |
| **Error** | 30 | 17877.17 | 595.9 | |
| CD (0.05) | 39.06 | | | |
| * Significant at 0.05 | | | | |

Table-14 presents the influence of various combinations of fertilizers on total root length. From the analysis, it is found that there were significant differences in the total root length of the plants having different treatments. The F value is computed as 2.27 and the CD value for the same was found to be 39.06. The result obtained is significant at 5%.

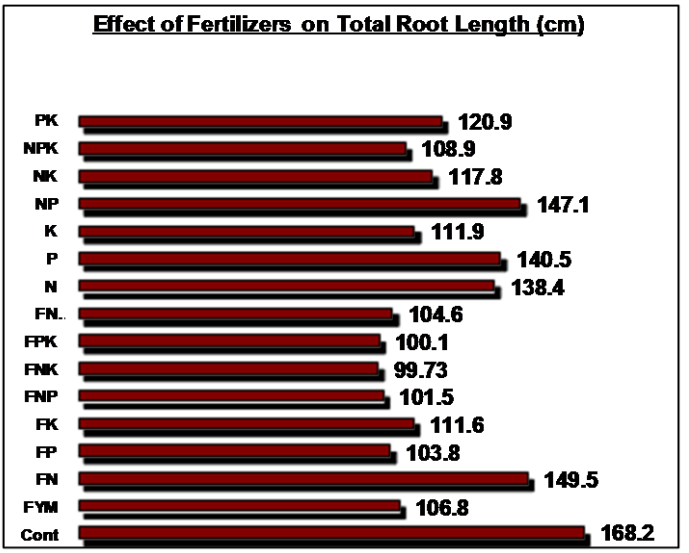



**Fig.-13: Effect of different fertilizers on root length of the plant**

Fig.-13 presents the result of the effect of various fertilizers affect the total root length of the plant. An examination of the fig. shows that total root length of the plant varies from 99.73 cm to 168.2 cm, maximum found in the control where no fertilizer had been used followed by 149.5 cm in FP and 147.1 cm in NP. Minimum root length was recorded in FNK (99.73 cm).

Significant decreases in the root lengths of the treatments F, K, NK, PK, NPK, FN, FK, FNP, FPK, FNK and FNPK were recorded when compared to control.

## Root Diameter

**Table-15: Analysis of variance of different fertilizers on root diameter**

| Source | df | SS | MS | F |
|---|---|---|---|---|
| **Treatment** | 15 | 20.62 | 1.37 | 1.21 |
| **Replication** | 2 | 3.97 | 1.98 | 1.75 |
| **Error** | 30 | 33.92 | 1.13 | |
| NS | | | | |

The results related to the effect of different fertilizers on root diameter are presented in table-15. The statistical analysis shows that the F value was found to be 1.21 and there was no significant difference between the maximum root diameters of the plants under various treatments.

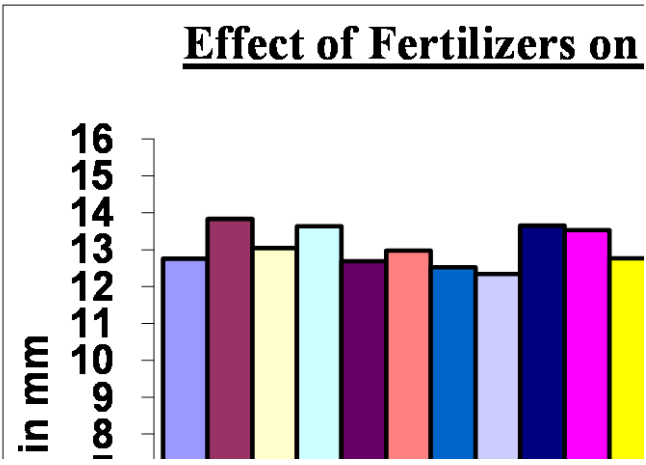



**Fig.-14: Showing influence of different fertilizers on root diameter**

Fig.-14 depicts the effect of different combinations fertilizers on the maximum root diameter. There is no significant difference in the root diameter of the plants under various treatments. However, it was ranged from 12.34 mm to 14.66 mm. Maximum recorded in the plants under the treatment NK followed by 14.21 mm and 13.83 in NP and F respectively whereas minimum was found in the treatment FPK (12.34 mm).

## Root Branches

**Table-16: Analysis of variance of different fertilizers on root branches**

| Source | df | SS | MS | F |
|---|---|---|---|---|
| **Treatment** | 15 | 61.31 | 4.09 | 1.61 |
| **Replication** | 2 | 32.67 | 16.33 | 6.45 |
| **Error** | 30 | 76 | 2.53 | |
| NS | | | | |

Table-16 presents the effect of application of different fertilizers on the number of root branches. The F value was found to be 1.61. However, results obtained regarding the differences in number of root branches under different treatments are not significant.

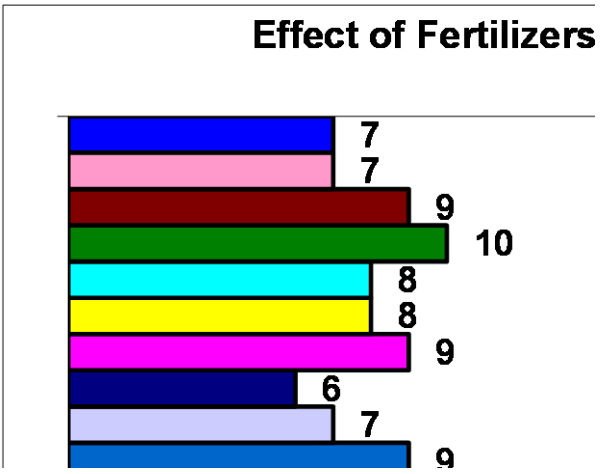



**Fig.-15 Effect of different fertilizers on number of root branches**

From a view on the fig.-15, it can be predicted that the number of root branches varies from 6 to 10. Maximum observed in the treatments FP, NP and control (10 nos.) and minimum in FNPK (6 nos.).

## Root Volume

**Table-17: Mean Value of Root Volume under different Treatments**

| Treatment | Root Volume (Mean) in cc |
|---|---|
| T | 96.4 |
| T 1 | 70.13 |
| T 2 | 71.33 |
| T 3 | 107.33 |
| T 4 | 81 |
| T 5 | 60.67 |
| T 6 | 59 |
| T 7 | 65.4 |
| T 8 | 69.67 |
| T 9 | 91 |
| T10 | 91.33 |
| T11 | 60.92 |
| T12 | 95.8 |
| T13 | 85.67 |
| T14 | 78 |
| T15 | 82 |

**Table-18: Analysis of variance of different fertilizers on root volume**

| Source | df | SS | MS | F |
|---|---|---|---|---|
| **Treatment** | 15 | 9643.88 | 642.92 | 2.36* |
| **Replication** | 2 | 1690.04 | 845.02 | 3.10 |
| **Error** | 30 | 8163.62 | 272.12 | |
| CD (0.05) | 26.4 | | | |
| * Significant at 0.05 | | | | |

The influence of different fertilizers on the root volume of the plants is depicted in tables-17 and 18. It varied from 59 cc to 107.33 cc. Maximum recorded in the treatment T3 followed by 96.4cc and 95.8 cc in the control and T12 respectively. Minimum was found in T6 (59 cc). The F value was calculated as 2.36 and the CD value was found to be 26.4. Significant decreases in root volumes were noted in the plants under the treatments T1, T5, T6, T7, T8 and T11 (70.13cc, 60.67cc, 59 cc, 65.4cc, 69.67 cc and 60.92 cc respectively) compared to control. The result obtained is significant at 5 %.

## Relationship between different variables of Root

Root variables include total root weight, fresh root weight, dry root weight, total root length, root diameter, number of root branches and root volume. The relationships between these were studied and the results obtained are presented in table-19.

**Table-19: Correlation Matrix of Root Yield (Total Weight, Fresh Weight, Dry Weight, Length, Diameter, Branches and Volume)**

| | T. Wt. | F. Wt. | D. Wt. | Length | Max. Dia. | Branch | Vol. |
|---|---|---|---|---|---|---|---|
| **T. Wt.** | 1.00 | - | - | - | - | - | - |
| **F. Wt.** | 0.958** | 1.00 | - | - | - | - | - |
| **D. Wt.** | 0.894** | 0.524** | 1.00 | - | - | - | - |
| **Length** | 0.804** | 0.402** | 0.575** | 1.00 | - | - | - |
| **Max. Dia.** | 0.457** | 0.491** | 0.512** | 0.220 | 1.00 | - | - |
| **Bran.** | 0.630** | 0.611** | 0.631** | 0.837** | 0.285* | 1.00 | - |
| **Vol.** | 0.929** | 0.951** | 0.927** | 0.835** | 0.491** | 0.929** | 1.00 |
| **N** | 48 | | | | | | |
| T. Wt.- Total weight; F. Wt.- Fresh weight; D. Wt.- Dry weight; Vol.- Volume. | | | | | | | |
| * Significant at .05 level, ** Significant at .01 level. | | | | | | | |

An examination of the table-19 interprets that there were positive relationship between total fresh root weight and fresh weight of roots (0.958), total fresh root weight and dry weight of roots (0.894), total fresh root weight and total length of roots (0.804), total fresh root weight and maximum diameter of the roots (0.457), total fresh root weight and number of root branches (0.630) and total fresh root weight and root volume (0.929) as well. All these are found significant at 1 percent. Similarly, fresh weights of the roots were significantly related with dry root weight, root length, maximum diameter, number of root branches and root volume. Dry weights of the roots were found positively related with root length, maximum diameter, numbers of root branches and volume of roots. Length of the root was found related with branch number and root volume. However, it was not related with maximum diameter of the root.

Maximum diameter of the root was positively related with number of root branches and root volume. The degree of relationship was found significant at 0.01 and 0.05 levels respectively. Number of root branches was significantly related with root volume and the degree of relationship was found to be 0.929 at 1 percent.

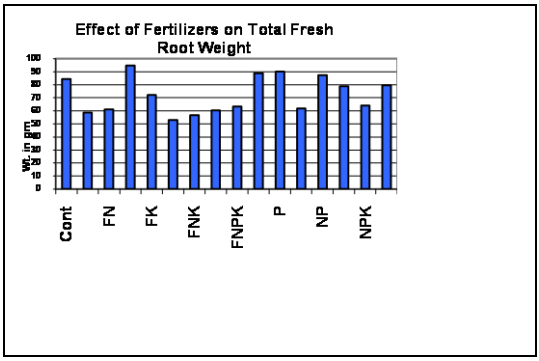



**Fig.-16: Showing effect of different fertilizers on total fresh root weight**

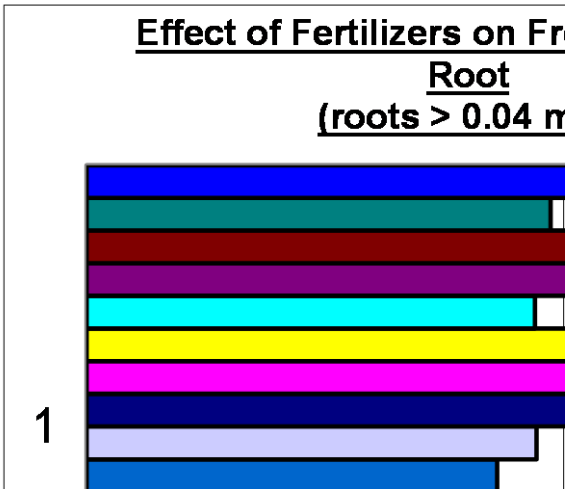



**Fig.-17: Effect of different fertilizers on fresh root weight (roots > 0.04 mm)**

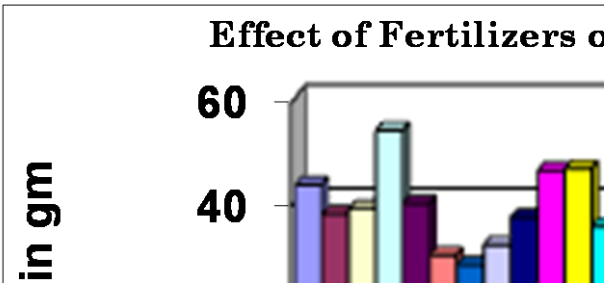



**Fig.-18: Showing effect of different fertilizers on dry root weight**

Very scanty and contradictory information is available regarding the effect of fertilizers on root yield of *R. serpentina*. The use of organic manure, leaf mould and compost has been recommended to increase the quality of nutrients in the soil and to improve water percolations. Dry root weight is found maximum under treatment FP i.e. 53.77 gm. The high yield is obtained when plants are raised from seeds in root trainers. Badhwar *et. al.,* (1963) reported that commercial plantations for root production should be best raised from seeds sown in April, under Dehradun conditions. Similarly, Nayar (1955) has also reported that in the case of one-year plants raised from seeds, the yield of roots is far higher than from those grown from cuttings. Anon (1997b) reported that heavy root is obtained, when *R. serpentina* is raised as a pure crop, the growing of intercrops gives larger overall profit. Rao *et. al.* (1999) suggested that the plants should be harvested after two years.

The results obtained show that application of FP resulted in high root yield of the plant i.e. increase in total fresh root weight, fresh root weight, dry root weight and root volume as well. The result achieved is in accordance with Sarin (1982) Maheshwari *et. al.,* (1988) and Jarayal, (2004). Sahu (1963) reported that *R. serpentina* responds to phosphates more than nitrogen. Phosphate induces more growth of thick and thin roots as reported by Farooqi and Sreeramu, (2001). Further, Jarayal (2004) found that combination of FYM and Phosphorus is effective for better growth of roots.

It appears that phosphorus is involved in better root development of the plant (Brady, 1984). It promotes early root formation and helps develop more rapidly (Gupta, 2003). The pH of the experimented soil was found to be 7.0 and availability of P is influenced by soil pH (6.0-7.0 range). Further, availability of other nutrients stimulates P uptake. It can be presummed that FYM applied to the soil is sufficient to release N, P and K, necessary for crop growth therefore, the combination of FP resulted in better root yield of the plant *R. serpentina.* The response due to application of phosphorus might be attributed to its involvement in the basic reaction of photosynthesis and root production (Kanwar, 1976; Maheshwari *et. al.,* 1988).

Maximum root length was found in the control. However, maximum root yield was observed under treatment FP. From the result obtained, it can be assumed that the roots of the plants under control gained more length but they were thin and thready as compared with the plants kept under different treatments.

Although, no significant difference was obtained in various treatments, maximum root diameter was recorded in the plants under treatment NK. Similar results have been observed by Russell (1977), Dahatoude *et. al.* (1983) and Anon (1977 a and b). Maximum number of root branches was recorded in the plants under treatment under NP, FP and control. However, no significant different was found between the numbers of root branches of the plant given varied treatments. Farooqi and Sreeramu (2001) have reported that phosphate induces growth of the roots. Significant difference in the total fresh weight of root was obtained with the use of different fertilizers. Maximum total root weight was recorded in the plants of treatment FP.

Use of fertilizers affects fresh root weight, as significant differences was recorded in fresh root weights of the different treatments. Maximum fresh root was obtained in the treatment FP. Similarly, use of various combination of fertilizers affect

dry root weight of the plant as significant difference was found in the dry root weights of different treatments. Maximum was recorded in FP. There were significant differences in the root length of the plants of different treatments. Maximum length was found in the control. Maximum root diameter was recorded in NK. However, no significant difference was obtained in different treatments. No significant difference was found in the number of root branches of different treatments. However, maximum number of root branches was recorded in NP, FP and control. Significant variations in the root volume of different treatments were obtained. Maximum root volume was recorded in the treatment FP. There are positive relationships between the various root-yielding characters. However, no relation was obtained between the root length and maximum root diameter.

## Conclusion

From the results obtained and discussions made, it can be concluded that application of fertilizers affects the root yield of *R. serpentina.* Application of FP or P is beneficial for root production. It seems that P is mainly concerned with increase in weight or quantity of *R. serpentina.* Since, phosphorus plays a significant role in the increase of biomass, therefore, it is recommended that for root production in quantity, application of 25 tons of FYM /ha and 30 kg of P/ha as basal dose is profitable for the cultivation of *R. serpentina.*

## REFERENCES

Anon (1997a). Progress of work for the period Jan. 1986-Dec. 1996 submitted to QRT on *AICRP on medicinal and aromatic plants.* Vol. 2 (Indore): 104-107.

Anon (1997b). Handbook of Agriculture. ICAR. New Delhi.

Anon, (1998). Medicinal plants of M.P.- Distribution, cultivation and trade. State forest research institute, Jabalpur, 49-51.

Anon. (2004). *Rauvolfia serpentina.* In Jari butiyon ki vayawasayic kheti. Udhyan avam JariButi Vibhag, Shantikunj. Yug Nirman Yojana, Gayatri Tapobhoomi, Mathura. 82-84pp.

Badhwar, R.L., Karira, G.V. and Ramaswami, S. (1955a). *Rauvolfia serpentina*- The wonder drug of India. *Indian Forester*. 81 : (4), 258-268.

Badhwar, R.L., Karira, G.V. and Ramaswami, S. (1956). *Rauvolfia serpentina*: Methods of propagation and their effect on production and alkaloidal content of root. *Indian Forest Leaflet*, No. 148.

Badhwar, R.L., Karira, G.V. and Ramaswami, S. (1963). *Rauvolfia serpentina*: Studies on optimum methods of propagation and their effect on production and alkaloidal contents of roots. *Indian Forester,* 89 : (11), 729-735.

Brady, N.C. (1984). Organic matters of mineral soils. In : *The nature and properties of soils.* Macmillan Publishing Company, New York.

Chandra, V. and Pandey, M.C. (2004). Jari butiyon ki kheti. ICAR, New Delhi, 254-263.

Cooke, G.W. (1972). Fertilizing for maximum yield. Crosby Lockwood and Son Ltd. London.

Dahatoude, B. N., Joshi, B. G. and Vitkare, D.G. (1983). Studies on response of nitrogen fertilization on the root yield of aswagandha (*Withania somnifera*). *PKV Res. J.* 7 : (1), 7-8.

Farooqi, A.A. and Sreeramu, B.S. (2001). Cultivation of medicinal and aromatic crops. 210-219.

Govil, J.N.; Pandey, J.; Shivkumar, B.G. and Singh, V.K. (2002). Recent progress in medicinal plants. SCI TECH Publishing LLC, Texas, U.S.A.

Gupta, P. K. (2003). Handbook of soil fertilizer and manure. Agrobotanica (India), Jodhpur.

Jarayal, G.S. (2004). Aushadhiya and Sugandhiya Paudhe. 3rd edition, Udhamita Vikas Kendra, Madhya Pradesh, Bhopal.

Kanwar, J.S. (1976). Soil fertility. *Theory and Practices,* ICAR, New Delhi.

Maheshwari, S.K.; Yadav, S., Gangrade, S.K. and Trivedi, K.C. (1988). Effect of fertilizers on growth, root and alkaloid yield of Rauvolfia (*R. serpentina*). *Indian Journal of Agricultural Sciences,* 58 : (6), 487-88.

Mathur, C.M. and Singh, S.P. (1965). Cultivation of *Rauvolfia serpentina* in Kota Forest Division (Rajasthan). *Indian Forester,* 91 : (4), 239-242.

Nair, R. K.N. (1955). *Rauvolfia serpentina* Benth.- Its importance and cultivation. *Indian Forester*, 81 : (3), 168-171.

Nayar, S.L. (1955). Experimental propagation and culture of *Rauvolfia serpentina* Benth. by seeds. CDRI, Paper presented in a three-day symposium on *Rauvolfia* at Calcutta.

Olsen, R. S. (1954). U. S. Dept. Agric. Circ., 939.

Piper, C.S. (1966). Soil and plant analysis. Hans Publishers, Bombay.

Rao, P.S., Venkaiah, K., Satyanarayana, V.V.V. and Padmaja, R. (1999). Cultivation of medical and aromatic plants. Research and development circle, A.P. Forest Dept., 6p.

Russell, R.S. (1977). *Plant root system : their function and interaction with soil.* McGraw-Hill Book Co. Limited. London, 296pp.

Sahu, B.N. (1963,I) Studies on *Rauvolfia serpentina* Linn. I-Effect of farmyard manure, ammonium sulphate and superphosphate on the yield of roots of *Rauvolfia serpentina* Linn. *Proc. 56th Ind. Sci. Cong. Part I.*

Sahu, B.N. (1963,II) Studies on *Rauvolfia serpentina* Linn. II-Response of *Rauvolfia serpentina* Linn. to the

application of nitrogen, phosphate and potash. *Proc. 56th Ind. Sci. Cong. Part II.*

Sahu, B.N. (1963,III) Studies on *Rauvolfia serpentina* Linn. III-Response of *Rauvolfia serpentina* Linn. to irrigation cum nitrogen and phosphate application. *Proc. 56th Ind. Sci. Cong. Part III.*

Sarin Y.K. (1982). Cultivation and utilization of *Rauvolfia serpentina* in India. In *Cultivation and utilization of medicinal plants*. Atal, C.K. and Kapur, B.M. (Eds.). Regional Research Laboratory, Jammu Tawi, Jammu & Kashmir. 288-294pp.

Sharma, R. (2005a). *Vanaushadhi Darpan*, 2 : 5-13.

Singh, H.P. (2001). National perspective on development of medicinal and aromatic plants. Technical report, Agri Watch.

Sobti, S.N., Abrol, B. K., Handa, K.L. and Chopra, I.C. (1959). Cultivation and *Rauvolfia serpentina* in Jammu and Kashmir. *Indian Forestor,* 85 : (4), 233-236.

Srivastava, N. and Kumar, S. (2003). Drug plant resources of Doon Valley. *Ann. Of For.,* 11 : (1), 63-84pp.

Subbiah, V. B. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* 25 : 259-261.

**Fig.-1: Transplanted Plot**

**Fig.-2:Excavation of Plant**

**Fig.-3: Excavation of Plant**

**Fig.-4: Washing Gently**

**Fig.-5: Weedfree Plots**

**Fig.-6: Data Collection**

**Fig.-7, 8 &9: Data Collection**