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Impact of integrated nutrient management on growth and yield of *Rauvolfia serpentina* Benth. Ex Kurz. in Jharkhand (India)

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Abstract
The experiment was conducted to know the impact of organic and inorganic fertilizer combination on growth and yield parameters of Sarpgandha plant. This experiment was conducted during 2018-20 at Birsa Agricultural University, Ranchi, Jharkhand (India). The experiment was laid out in Randomized Block Design with 12 treatments and one control replicated thrice. Number of plants in each treatment was 12. Maximum plant height (62.83 cm) and Collar Diameter (9.29 mm) of Sarpgandha was recorded in 7.5 t ha^{-1} Vermicompost (VC) + 5 t ha^{-1} Neem Cake (NC) + 7.5 t ha^{-1} Karanj Cake (KC) + 50:50:50 kg NPK ha^{-1}. Maximum primary root length (61.75 cm) and fresh root yield per hectare (2846.67 kg/ha) were recorded in 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}. Maximum secondary root length (46.67 cm) was recorded in 7.5 t ha^{-1} VC + 5t ha^{-1} NC + 7.5 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}). Maximum root collar diameter (11.43 mm) was also found in 7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}. Maximum number of secondary root (6.53) was observed in 5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}. The maximum dry root yield per hectare (1455.60 kg/ha) was recorded in 7.5 t ha^{-1} VC + 5 t ha^{-1} NC+7.5 t ha^{-1} KC +30:40:40 kg NPK ha^{-1}. it can be concluded that the best combination of organic and inorganic fertilizer application are 7.5 t ha^{-1} VC+5 t ha^{-1} NC+7.5 t ha^{-1} KC +30:40:40 kg NPK ha^{-1} $^{+}$ and 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1} which provide the maximum production of dry root yield and fresh root yield per hectare respectively.

Keywords: Sarpgandha, *Rauvolfia serpentina*, Fertilizer, organic, inorganic, vermicompost (VC), Karanj Cake (KC), Neem Cake (NC), NPK, yield

Introduction
Medicinal plants have been used for the treatment of human diseases since time immemorial. In Jharkhand, because of the presence of acidic soil micro and macro nutrients are not available to plant, therefore growth is being affected. The application of fertilizers would be helpful to improve the physical and chemical properties of soil which are very much important to cope with different environmental factor and improve production and productivity.

The pharmacological activity of the roots is attributed to the presence of several alkaloids which is affected due to nutritional status of the soil (Maheshwari *et al.*, 2000) [4]. The use of judicious combination of organic and inorganic fertilizer source is essential not only to maintain soil health but also sustain productivity (Malewar *et al.*, 1998) [5]. Proper nutrient management plays important role in stimulating early root growth and development.

Rauvolfia serpentina (L.) Benth. Ex Kurz. commonly known as Sarpgandha (Indian snakeroot) is critically endangered medicinal plant species. It is an important medicinal plant found in Indian subcontinent and south East Asian countries. It belongs to the family apocynaceae and its habit is evergreen, perennial, glabrous and erect under shrub, 60-90 cm in height and grows generally in the region with annual rainfall of 200-250 cm and up to an altitude of 1300-1400 m. Leaves are simple, 7.5 cm long and 3.5 - 5 cm broad, elliptic or lanceolate, glabrous, bright-green above and pale green beneath and occurring in whorls of 3-5. The inflorescence is a many flowered corymbs with white or pink flowers. The fruit is a drupe, 0.5 cm in diameter and shiny black when fully ripe. The root system consists of a prominent, tuberous, soft tap-root, reaching a length of 30-50 cm in a 2 year old plant. Its diameter at the thickest portion varies from 1.2 to 2.5 cm. The root-bark, which constitutes 40-60% of the whole root, is rich in alkaloids. Breeding behavior is self to often cross-pollinated. The fresh roots emit a

characteristic acrid aroma and are very bitter in taste. Main objective of this experiment was to screen out the optimum doses of organic and inorganic fertilizers to optimize the growth and yield of Sarpgandha and also screen out the impact on root yield.

Methodology

The experiment was conducted from August, 2018 to February, 2020 in the experimental field (D-Block) of Birsa Agricultural University, Ranchi. The university is located in between 23° 26 N latitude and 85° 19 /E longitude. The altitude is about 622 m above the mean sea level.

The experiment was laid out in Randomized Block Design with 12 treatments and one control replicated thrice. Number of plants in each treatment was 12. Growth parameters and yield parameters like plant height (cm), collar diameter (mm), number of branches, root length, root yield/ha etc. were recorded as per NBPGR format (Singh *et al*., 2003) [7] at different growth stages. The treatments are control and combination of organic and inorganic fertilizers. Treatment details are T_0- Control, T_1- 5 t ha^{-1} VC + 5 t ha^{-1} KC + 5 t ha^{-1} NC + 30:40:40 kg NPK ha^{-1}, T_2- 7.5 t ha^{-1} VC + 7.5 t ha^{-1} KC+7.5 t ha^{-1} NC + 40:50:40 kg NPK ha^{-1}, T_3- 10 t ha^{-1} VC + 10 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}, T_4- 5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}, T_5- 5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}, T_6- 5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}, T_7- 7.5t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}, T_8- 7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}, T_9- 7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}, T_{10}- 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}, T_{11}- 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 40:50:50 kg NPK ha^{-1} and T_{12}- 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1} (VC-Vermicompost, KC- Karanj Cake, NC- Neem Cake, NPK-Nitrogen, Phosphorus, and Potassium)

Results and Discussions

Maximum plant height (62.83 cm) and Collar Diameter (9.29 mm) of Sarpgandha was recorded in T_9 (7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}) and minimum height (53.60 cm) was in T_0 (Control) and minimum collar diameter (6.99 mm) was in T_{12} (10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}). Thakur *et al*. (2014) [8] revealed the application of N dose of 120 kg/ha produced the tallest plants (44.55 cm) whereas, 40 kg N/ha produced the shortest (28.87cm). Patil *et al*., (2014) [10] revealed on use of organic and chemical fertilizers showed that significant effect on growth parameters in Ashwagandha.

Maximum primary number of branches (10.23) was recorded in T_4 (5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}) and minimum (7.49) was in T_{10} (10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}).

Table 1: Mean values of plant height, collar diameter and number of branches of different fertilizer treatments of Sarpgandha

Treatment	Fertilizer combination (VC-Vermicompost, KC- Karanj Cake, NC- Neem Cake)	Plant height (cm)	Collar Diameter (mm)	No. of Branches
T_1	5 t ha^{-1} VC + 5 t ha^{-1} KC + 5 t ha^{-1} NC + 30:40:40 kg NPK ha^{-1}	55.91	7.53	8.00
T_2	7.5 t ha^{-1} VC + 7.5 t ha^{-1} KC+7.5 t ha^{-1} NC+40:50:40 kg NPK ha^{-1}	53.40	7.82	8.47
T_3	10 t ha^{-1} VC + 10 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}	60.13	8.03	7.87
T_4	5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}	57.93	8.19	10.23
T_5	5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}	61.35	9.06	9.60
T_6	5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}	56.27	7.28	7.73
T_7	7.5t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}	56.53	7.84	8.35
T_8	7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}	58.47	7.87	7.68
T_9	7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}	62.83	9.29	9.00
T_{10}	10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}	56.16	7.53	7.49
T_{11}	10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 40:50:50 kg NPK ha^{-1}	58.57	7.80	10.17
T_{12}	10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}	54.12	6.99	7.73
T_0	Control	53.60	7.52	7.80
	Grand Mean	57.33	7.90	8.47
	SEM	3.603	0.34	0.48
	CV%	10.89	7.48	9.71

The maximum primary root length (61.75 cm) and fresh root yield per hectare (2846.67 kg/ha) were recorded in T_{10} (10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1}) and minimum (45.50 cm) primary root length and fresh root yield per hectare (2306.67 kg/ha) were in control. Patil *et al*. (2014) [10] founded that there was a significant maximum fresh and dry root yield of Ashwagangha (13.68 q/ha and 11.09 q/ha, respectively) were recorded in 2 t FYM/ha + 0.5 t VC/ha + 20:30:20 kg NPK/ha.

Maximum secondary root length (46.67 cm) was recorded in T_8 (7.5 t ha^{-1} VC + 5t ha^{-1} NC + 7.5 t ha^{-1} KC + 40:50:40 kg NPK ha^{-1}) and minimum (36.53 cm) was in T_9 (7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}). Maximum root collar diameter (11.43 mm) was also found in T_9 (7.5 t ha^{-1} VC + 5 t ha^{-1} NC + 7.5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}) and minimum (8.21 mm) was in control. The cultivation of Sarpgandha plant in India was reported by many authors (Biswas, 1956; Dutta *et al*., 1963; Badhwar *et al*., 1955) [2, 3, 1].

Table 2: Mean values of primary root length, secondary root length, collar diameter, no. of secondary root, fresh root yield/ha and dry root yield/ha of different fertilizer treatments of Sarpgandha

Treatment	Primary Root Length (cm)	Secondary Root Length (cm)	Collar Diameter (mm)	No. of Secondary Root	Fresh Root Yield/Ha (Kg/ha)	Dry Root Yield/Ha (Kg/ha)
T_1	48.60	40.67	10.81	4.83	2654.44	1089.87
T_2	48.19	40.67	10.86	5.47	2734.40	1074.13
T_3	45.61	39.06	10.63	5.33	2543.33	1072.00

T_4	51.08	44.81	8.94	5.57	2623.33	1217.33
T_5	50.94	43.44	10.45	5.28	2693.33	1194.67
T_6	48.00	39.17	9.97	6.53	2533.33	1056.13
T_7	49.49	38.94	10.70	5.56	2720.00	1455.60
T_8	57.67	46.67	8.23	5.89	2671.16	1294.40
T_9	57.00	36.53	11.43	5.62	2698.89	1248.53
T_{10}	61.75	45.17	10.45	6.31	2846.67	1293.47
T_{11}	46.06	39.69	9.70	6.06	2478.89	1041.33
T_{12}	49.89	42.44	10.48	4.53	2648.89	1081.24
T_0	45.50	41.92	8.21	4.81	2306.67	1020.07
G. Mean	50.75	41.47	10.06	5.52	2627.18	1164.52
SEM	3.52	4.71	0.72	0.60	180.40	86.28
CV%	12.01	19.67	12.44	18.70	11.89	12.83

Maximum number of secondary root (6.53) was observed in T_6 (5 t ha^{-1} VC + 7.5 t ha^{-1} NC + 10 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}) and minimum was in T_{12} (10 t ha^{-1} VC + 10 t ha^{-1} NC +5 t ha^{-1} KC + 50:50:50 kg NPK ha^{-1}). Maximum fresh root yield (2846.67 kg/ha) was calculated from T_{10} and minimum (2306.67 kg/ha) from control while the grand mean value was 2627.18 kg/ha. However, maximum dry root yield per hectare (1455.60 kg/ha) was recorded in T_7 (7.5t ha^{-1} VC+5t ha^{-1} NC+7.5t ha^{-1} KC +30:40:40 kg NPK ha^{-1}) while the minimum (1020.07 kg/ha) was in control. Vajantha *et al*. (2014) [9] reported the results of two years study indicated that the dry root yield was significantly influenced due to both fertilizer levels, organic manures as well as with their interaction.

Picture 1: Experimental Plot

Picture 2: Application of fertilizers

Picture 3: Sarpgandha Plants and Sarpgandha Roots

Picture 4: Sarpgandha Root Length

Conclusion

From above result it can be concluded that the best combination of organic and inorganic fertilizer application are 7.5 t ha^{-1} VC+5 t ha^{-1} NC+7.5 t ha^{-1} KC +30:40:40 kg NPK ha^{-1} and 10 t ha^{-1} VC + 10 t ha^{-1} NC + 5 t ha^{-1} KC + 30:40:40 kg NPK ha^{-1} which provide the maximum production of dry root yield and fresh root yield per hectare respectively.

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