

Uptake of nutrients, root yield and quality of ashwagandha (*Withania somnifera* Dunal) as influenced by harvesting period

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SUMMARY

A field experiment to study the uptake of nutrients, root yield and quality of ashwagandha (*Withania somnifera* Dunal) as influenced by harvesting period was conducted at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during 2003-04. The soil of the experimental site was slightly calcareous, alkaline and clayey in texture, sufficient in available K, however, low in organic carbon, available N and Olsen's P. The treatments were comprised of five harvesting time viz., T₁- At flowering initiation, T₂- 50% flowering, T₃-100 % flowering, T₄-Berry ripening and T₅-At maturity tried in Randomized Block Design with four replications. The content of N, P, K and S in dry matter was decreased with the harvesting time in dry matter as well as in roots. The uptake of N was significantly increased up to 50% flowering stage. P and S were significantly increased up to berry ripening stage and K uptake was noticed highest at maturity stage. The content of micronutrients (Zn, Fe, Mn, Cu and B) was also decreased with the harvesting time in dry matter as well as roots. The uptake of micronutrients increased with the harvesting time. Zn was noticed maximum at 100% flowering stage and Fe was noticed maximum at berry ripening stage. Significantly highest root yield was recorded with the harvesting at 100% flowering stage over all the treatments except berry ripening stage. The crude content was found to increase with the harvesting time. The highest fibre content was recorded at maturity stage. The total alkaloids content was significantly highest at 50% flowering stage followed by 100% flowering stage. Significantly lowest content was noticed at flower initiation stage. However, the yield of total alkaloids was significantly highest with 100% flowering stage over all the treatments. The total uptake of P, Fe, Cu were contributed for synthesis of total alkaloids in the Ashwagandha roots which ultimately results in to positive significant correlation.

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Key words : *Withania somnifera*, Nutrient uptake, Total alkaloids

Ashwagandha or Asgandh (*Withania somnifera* Dunal) is the member of nightshade family *i.e.* Solanaceae. It is an erect, herbaceous, evergreen, tomentose shrub with 13 to 50 cm height. The crop is being commercially cultivated on an area of around 10,000 ha in India mostly in Madhya Pradesh. Traditionally as a medicine Ashwagandha has been used in many ways, as a sedative, diuretic, a rejuvenating tonic. Ashwagandha roots are also used for a wide range of ailments including arthritic inflammation, insomnia, cough, nervous disorders, gynecological disorders, especially functional female and male fertility and impotence. The pharmacological activity of the roots is attributed to the alkaloids present in it.

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Ashwagandha has assumed great importance now a days due to its good domestic market value and potential. The research work on the stages of harvesting and its effect of root quality is very meagre. Due to its constant demand, good market price and important medicinal value, area under ashwagandha is increasing day by day. The local farmers have queries about its package of practices particularly stage of harvesting and nutritional management and, therefore, the present investigation was carried out.

MATERIALS AND METHODS

A field experiment was conducted under All India Networking Project on Medicinal and Aromatic Plants (ICAR), Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola during *Kharif* 2004-2005.

The soil of the experimental site was clayey, calcareous, alkaline in reaction, and sufficient in available K, however, low in organic carbon, available N and Olsen's P. The treatments were comprised of five harvesting time

viz., T₁-At flowering initiation, T₂- 50% flowering, T₃- 100 % flowering, T₄-Berry ripening and T₅ -At maturity tried in Randomized Block Design with four replications. The growth observations as well as post harvest observations were recorded as per the treatments. The total alkaloid content was determined as per the titrimetric method (Anonymous, 1998) and crude fibre content was estimated by the method described by Chopra and Kanwar (1980). The nutrients content in plant and roots was estimated by adopting the standard analytical procedures (Chesnin and Vein, 1950; Hatcher and Wilox, 1950; Jackson, 1976 and Piper, 1966).

RESULTS AND DISCUSSION

The results obtained from the present investigation have been discussed in the following sub heads :

Content and uptake of nutrients:

Growth, nutrient content and uptake by plants vary in different localities due to factors such as natural conditions of soil, climate and cultural practice which among other things include crop species, crop varieties, methods of cultivation etc. (Ishizuka, 1971). The study of nutrient uptake by the crop plant is useful in determining

the peak period of its uptake for its nutritional management. In the present study the nutrient uptake studies at various harvesting period were undertaken for nontraditional and important medicinal crop plant *viz.*, Ashwagandha.

The data presented in Table 1 and 2 revealed that in general the content of nutrients (Macro and micro) of dry matter as well as of roots was found to decrease with the advancement in harvesting period. Further, it was noticed that the content of nutrients was successively decreased after the growth stage of 50% flowering.

The total N uptake was significantly increased up to 100% flowering (Table 3). The highest uptake was noticed at 100% flowering stage and latter on it decreased significantly at berry ripening and maturity stage. The uptake of P and S were significantly increased up to berry ripening stage. However, K uptake was noticed highest at maturity stage and it was statistically at par with 100% flowering and berry ripening stage.

The total uptake of micronutrients (Zn, Fe, Mn, Cu and B) was also increased with the harvesting period. Further, the significantly highest uptake of Zn, Mn and B was noticed at maturity stage, while the Fe and Cu uptake was recorded highest with berry ripening and 100% flowering stage, respectively (Table 4).

Table 1: Macro-nutrient content of dry matter and roots at different harvesting period

Harvesting period	Contents of major nutrients (%)								
	Dry Matter				Roots				
	N	P	K	S	N	P	K	S	
T ₁ -Flower initiation	0.241	0.190	0.441	0.043	0.130	0.13	0.265	0.022	
T ₂ -50 % flowering	0.356	0.177	0.332	0.056	0.094	0.12	0.238	0.039	
T ₃ - 100 % flowering	0.307	0.157	0.350	0.051	0.116	0.12	0.231	0.038	
T ₄ - Berry ripening	0.228	0.150	0.316	0.048	0.110	0.13	0.193	0.036	
T ₅ - Maturity	0.204	0.145	0.318	0.040	0.10	0.12	0.184	0.034	
S.E. (m) ±	0.022	0.001	0.007	0.003	0.004	0.094	0.005	0.002	
C.D. (P=0.05)	0.069	0.005	0.214	0.007	0.013	0.006	0.176	0.005	
C.V. (%)	16.88	2.17	3.95	9.39	7.54	2.90	5.38	10.09	

Table 2: Micro-nutrient content of dry matter and roots of ashwagandha at different harvesting period

Harvesting period	Contents of Micro-nutrients (ppm)									
	Dry Matter					Roots				
	Zn	Fe	Mn	Cu	B	Zn	Fe	Mn	Cu	B
T ₁ -Flower initiation	18.10	664.78	94.35	88.08	0.022	42.85	540.63	88.00	143.18	0.030
T ₂ -50 % flowering	16.66	838.70	98.13	83.70	0.048	42.18	527.2	88.70	133.35	0.052
T ₃ - 100 % flowering	14.33	754.35	90.93	75.75	0.060	41.53	456.53	90.40	126.95	0.055
T ₄ - Berry ripening	13.65	736.63	90.18	67.28	0.063	41.28	340.18	90.84	115.6	0.060
T ₅ - Maturity	13.30	682.15	90.10	57.68	0.068	40.93	344.10	91.18	105.35	0.051
S.E. (m) ±	0.35	10.62	5.05	1.13	0.006	0.302	10.90	1.68	2.96	0.008
C.D. (P=0.05)	1.06	32.73	15.56	3.48	0.020	0.928	33.62	5.18	9.13	0.25
C.V. (%)	4.53	2.90	10.90	3.03	25.09	1.45	4.92	3.74	4.75	31.96

These results are supported by findings of Wankhade *et al.* (1997) who studied the macro and micro nutrient uptake pattern of some field crops and reported that the contents in plants decreased as the plant growth progressed towards physiological maturity. In sorghum, groundnut and soybean the uptake rate of nutrients was slow up to 45 days and rapid to vary during 45-60 days of growth period. However, the uptake rate of nutrients was found more during 60-75 days growth period of pigeonpea and cotton. In green gram and wheat the peak period of nutrient uptake was found to be 35-45 days of crop growth. In present study the data on total nutrient uptake status indicated the peak period of macro as well as micro nutrients uptake by Ashwagandha crop was during 50 % to 100 % flowering stage.

Root yield and its quality:

The root length was successively increased with the harvesting period. At the flower initiation stage root length was 11.6 cm and it was significantly increased up to berry ripening and maturity stage (19.5 cm), however, it was at par with 100% flowering stage. The dry root yield was also influenced by time of harvest. The dry root yield was increased with the harvesting time up to 100% flowering stage and significantly highest root yield was recorded at this growth stage (Table 5).

The total alkaloid content increased successively up to 100% flowering stage and the highest content (0.620%) was recorded with 100% flowering. The lowest content (0.516%) was noticed at flower initiation stage. The total alkaloid yield was calculated by multiplying content of total alkaloids with dry root yield at respective stage of harvesting. The alkaloid yield was also significantly higher at 100% flowering stage. However, it was at par with berry ripening and maturity stage.

The crude fiber content was increased successively with each harvesting period and significantly higher content (26.8%) was registered at maturity stage. However, it was at par with berry ripening stage. Higher crude fiber content is not desirable character in respect of quality aspect and, therefore, the root having lower fiber content is preferred by pharmaceutical industry. In present investigation the total alkaloids content as well as alkaloid yield were maximum at 100% flowering stage with comparatively low content of crude fiber (23.7%). These results are in agreement with the findings of Mandsaur and Udaipur Centre (Anonymous, 2003).

Correlation studies:

The uptake of nutrients at various harvesting periods had exhibited positive association with that of total alkaloids yield (Table 6). The data was further subjected to path

Table 3 : Total uptake (Dry matter + roots) of macro-nutrients by ashwagandha

Harvesting period	Dry matter accumulation (qha ⁻¹)	Total uptake of nutrients (kg ha ⁻¹)			
		N	P	K	S
T ₁ -Flower initiation	13.03	3.40	2.83	6.43	0.609
T ₂ -50 % flowering	23.67	8.80	4.74	8.89	1.500
T ₃ - 100 % flowering	45.60	14.44	7.77	17.13	2.515
T ₄ - Berry ripening	51.25	12.28	8.38	17.27	2.678
T ₅ - Maturity	53.00	11.30	8.35	17.89	2.299
S.E. (m) ±	1.27	0.60	0.18	0.47	0.090
C.D. (P=0.05)	3.92	1.84	0.53	0.14	0.280
C.V. (%)	6.81	11.89	5.36	6.99	9.47

Table 4 : Total uptake (dry matter + roots) of micro-nutrients by ashwagandha

Harvesting period	Total uptake of micro nutrients				
	Zn (gha ⁻¹)	Fe (gha ⁻¹)	Mn (gha ⁻¹)	Cu (gha ⁻¹)	B (mgha ⁻¹)
T ₁ -Flower initiation	35.00	1010.53	146.54	151.97	34.76
T ₂ -50 % flowering	57.70	2214.34	270.73	255.95	134.14
T ₃ - 100 % flowering	88.72	3696.29	468.03	416.88	299.58
T ₄ - Berry ripening	92.56	3962.17	515.24	407.96	351.46
T ₅ - Maturity	92.80	3799.08	525.18	363.07	386.80
S.E. (m) ±	3.18	111.44	29.49	11.60	22.16
C.D. (P=0.05)	9.80	343.35	90.84	35.76	68.27
C.V. (%)	8.68	7.59	18.30	7.27	18.37

Table 5 : Root yield of Ashwagandha and its quality as influenced by harvesting period

Harvesting period	Root length (cm)	Dry root yield (qha ⁻¹)	Total alkaloid (%)	Alkaloid yield (qha ⁻¹)	Crude fibre (%)
T ₁ -Flower initiation	11.6	2.67	0.516	1.372	14.72
T ₂ -50 % flowering	16.4	4.39	0.617	2.682	24.09
T ₃ - 100 % flowering	19.4	5.64	0.620	3.500	23.67
T ₄ - Berry ripening	19.5	5.47	0.598	3.282	26.10
T ₅ - Maturity	19.5	5.42	0.595	3.222	26.83
S.E. (m) ±	0.41	0.23	0.019	0.202	0.69
C.D. (P=0.05)	1.26	0.71	0.059	0.624	2.10
C.V. (%)	4.79	9.78	6.60	14.40	6.09

Table 6 : Correlation matrix of total uptake of nutrients with total alkaloids yield of Ashwagandha (Direct and indirect effect on main and diagonal)

Para meters	r ²	Total uptake of nutrients						
		N	P	K	Fe	Mn	Cu	B
N	0.820**	0.212	0.717**	-0.241	0.462*	-0.553**	0.493*	-0.208
P	0.871**	0.185	0.821**	-0.279	0.516*	-0.651**	0.516*	-0.237
K	0.853**	0.181	0.812**	-0.282	0.504*	-0.667**	0.511*	-0.236
Fe	0.856**	0.188	0.815**	-0.273	0.520*	-0.648**	0.517*	-0.233
Mn	0.806**	0.174	0.793**	-0.267	0.500*	-0.674**	0.498*	-0.220
Cu	0.991**	0.195	0.791**	-0.269	0.502*	-0.626**	0.536*	-0.218
B	0.801**	0.176	0.780**	-0.266	0.486*	-0.593**	0.467*	-0.249

* and ** indicate significance of values at P=0.01 and 0.05, respectively,

Residual effect = 0.1317

analysis as it provides an effective means for finding out direct and indirect causes of association and permits a critical examination of the specific forces acting to produce a given correlation.

It was observed that the total uptake of K and B had negative direct effect on total alkaloids yield; however, the association could reach to level of significance with total uptake of Mn and Fe. Among the indirect effect maximum positive influence on total alkaloids yield was

due to total uptake of P, Fe, and Cu resulted in to significant positive correlation with total alkaloids yield.

The results clearly indicated that total uptake of P, Fe, and Cu were contributed for synthesis of total alkaloids in the Ashwagandha roots which ultimately resulted in to positive significant correlation.

A close relationship has been found to exist between the nutrient metabolism in plants and secondary metabolites.

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