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Influence of different nitrogen levels and harvesting stages on nutrient uptake and available nutrients in ashwagandha (*Withania somnifera* L. Dunal)

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Abstract

The field experiment was carried out at at Krishi Vigyan Kendra, University of Agricultural Sciences, Raichur, Karnataka in medium black clayey soil during 2021-22 to study the influence of different nitrogen levels and harvesting stages on nutrient uptake and available nutrients in Ashwagandha [*Withania somnifera* (L.) Dunal]. Experiment was laid out in split plot design with treatment combinations. The main plot consists of four nitrogen levels (N) viz., N₀: 0 kg N ha, N₁: 20 kg N ha, N₂: 40 kg N ha and N₃: 60 kg N ha. Whereas, sub plot consists of four different stages of harvest (H) viz., H₁: 90 DAS, H₂: 110 DAS, H₃: 130 DAS and H₄: 150 DAS. The nutrient uptake by the plants and available nutrients in the soil after harvest were significantly influenced and varied by the combination effect of different nitrogen levels and harvesting stages. The highest nitrogen, phosphorus and potassium uptake and maximum soil available nitrogen, phosphorus and potassium were recorded with the application of 40 kg N ha⁻¹ and harvested at 150 DAS (N₂H₄).

Keywords: Ashwagandha, nitrogen, phosphorus, potassium, harvesting stage

Introduction

Ashwagandha was first mentioned by sage Punarvasu Atreya over 4000 years ago. Subsequently, the medicinal properties of this plant were mentioned in Ayurvedic treatises such as Charaka Samhita, Sushruta Samhita, Astanga Hridaya, Bhava Prakasha Nighantu, etc. to mention a few. Currently around 200 traditional medicinal formulae are prepared in Ayurveda, Siddha and Unani systems using this plant (Bhushan *et al.*, 2004) ^[1]. Karnataka is one of the immensely potential states for the cultivation of medicinal plants as it is blessed with a wide range of climatic conditions and the tropical forests of the Western Ghats and deciduous forests of the Deccan plateau which are rich in medicinal plants with more than 2500 species in its biodiversity (Shilpa *et al.*, 2020) ^[7].

Ashwagandha being a solanaceous crop the deficiency of nitrogen may limit the crop growth, chlorophyll content and production of secondary metabolites. Harvesting is the most critical stage in medicinal plants, as this ensures maximum levels of active ingredients and better quality. Hence, stage of harvest is most important factor to obtain good quality end product. Keeping this in view “The influence of different nitrogen levels and harvesting stages on nutrient uptake and available nutrients in ashwagandha (*Withania somnifera* L. Dunal)”

Materials and Methods

The experiment was carried out in medium black soil at ICAR-Krishi Vigyan Kendra, Raichur during 2021-22. The region falls under Agro-Climatic Zone-II North-Eastern dry zone of Karnataka. Raichur is located at 16° 19' N latitude, 77° 31' E longitude and an altitude of 407 meters above the mean sea level.

Ashwagandha variety Jawahar Asgandh-20 has been used for the experiment. The recommended dose of farm yard manure @ 5 t ha⁻¹, phosphorus @ 20 kg ha⁻¹ in the form of single super phosphate, potassium @ 60 kg ha⁻¹ in the form of muriate of potash and nitrogen (0, 20, 40 and

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60 kg ha⁻¹) in the form of urea was applied as per the treatments. After the harvest of the crop at different stages, the plant samples were subjected for major nutrients (NPK uptake) analysis and soil was collected for the analysis of available nutrients in the soil.

Results and Discussion

Nutrient uptake: Influence of nitrogen levels, stages of harvest and their interaction effect on nitrogen, phosphorus and potassium uptake by ashwagandha are presented in table 1.

Nitrogen uptake by ashwagandha plants showed significant difference with nitrogen levels, stages of harvest and its interaction effect. Among the different nitrogen levels, the highest nitrogen uptake per hectare (184.7 kg) was recorded with the application of 60 kg N ha⁻¹ (N₃) followed by 40 kg N ha⁻¹ (N₂) (166.8 kg). Crop harvested at different intervals differed significantly. The highest uptake of nitrogen per hectare (170.4 kg) was recorded in crop harvested at 150 DAS (H₄) as compared to crop harvested at 90 DAS (H₁) (126.3 kg). The interaction effect of nitrogen levels and stages of harvest showed significant difference with nitrogen uptake. Crop supplied with 60 kg N ha⁻¹ and harvested at 150 DAS (N₃H₄) recorded highest nitrogen uptake per hectare (197.0 kg) which was on par with the application of 40 kg N ha⁻¹ and harvested at 150 DAS (N₂H₄) (196.5 kg) and the lowest (75.3 kg) was recorded in crop grown without nitrogen application and harvested at 90 DAS (N₀H₁).

Among the different nitrogen levels, the highest phosphorus uptake per hectare (23.60 kg) was recorded with the application of 40 kg N ha⁻¹ (N₂) followed by 60 kg N ha⁻¹ (N₃) (22.69 kg). The lower phosphorus uptake (16.06 kg) was reported in the treatment with no nitrogen application. Crop harvested at different intervals differed significantly and the highest uptake of phosphorus per hectare (23.24 kg) was recorded in crop harvested at 90 DAS (H₁) as compared to crop harvested at 150 DAS (H₄) (16.10 kg). The interaction effect of nitrogen levels and stages of harvest does not show any significant difference with phosphorus uptake.

Potassium uptake by ashwagandha was showed significant difference with different nitrogen levels, stages of harvest and their interaction effect. Among the different nitrogen levels, the highest potassium uptake per hectare (119.3 kg) was recorded with the application of 40 kg N ha⁻¹ (N₂) which was on par with the application of 60 kg N ha⁻¹ (N₃) (110.7 kg). The minimum uptake of potassium per hectare (65.9 kg) was recorded in crop grown without nitrogen (N₀) application. Crop harvested at different intervals differed significantly and recorded the highest uptake of potassium per hectare (125.0 kg) in crop harvested at 150 DAS (H₄) as compared to crop harvested at 90 DAS (H₁) (71.5 kg). The interaction effect of nitrogen levels and stages of harvest showed significant difference with potassium uptake. Crop supplied with 40 kg N ha⁻¹ and harvested at 150 DAS (N₂H₄) recorded highest potassium uptake per hectare (147.6 kg) which was on par with the application of 60 kg N ha⁻¹ and harvested at 150 DAS (N₃H₄) (141.5 kg) and the lowest (42.1 kg) was recorded in crop harvested at 90 DAS without nitrogen (N₀H₁) application.

Highest uptake of nitrogen and phosphorus was recorded at peak

vegetative growth stage in crop supplied with higher nitrogen levels (60 kg ha⁻¹) as compared to without nitrogen application. The nitrogen uptake was found high and reached maximum during vegetative growth and the uptake pattern flattens off as N is moved or reallocated from the vegetative components to reproductive structures. Whereas, the applied nitrogen significantly increased the translocation rate during the vegetative growth stage, thereby increase in phosphorus absorption was noticed in crop provided with optimum level of nitrogen. There is a synergistic effect with nitrogen and potassium ratio. As the nitrogen level increases the increase in potassium uptake can be seen. These findings were found similar with the results obtained by Kumar *et al.* (2001)^[5] in Onion, Kiruthikadevi (2002)^[4] in ashwagandha, Sailaja *et al.* (2007)^[6] in coleus.

Available nutrients: Influence of nitrogen levels, stages of harvest and their interaction effect on available nitrogen, phosphorus and potassium in soil after harvest of ashwagandha are presented in table 2.

The available nitrogen in soil per hectare was found highest (234 kg) in the treatment supplied with 60 kg N ha⁻¹ (N₃) which was on par with the treatment supplied with 40 kg N ha⁻¹ (N₂) (212 kg). The lowest quantity of available nitrogen per hectare (143 kg) was recorded in the treatment without nitrogen (N₀) application. The crop harvested at different intervals was found significant and highest available nitrogen per hectare (213 kg) was found in crop harvested at 90 DAS (H₁) and the lowest (177 kg) was found in crop harvested 150 DAS (H₄). The interaction effect of nitrogen levels and stages of harvest was found significant. The highest available nitrogen per hectare (248 kg) was recorded in crop supplied with 60 kg N ha⁻¹ and harvested at 90 DAS (N₃H₁). The lowest (124 kg) was recorded in the treatment without nitrogen application and harvested at 150 DAS (N₀H₄).

The available phosphorus and potassium in soil after harvest of ashwagandha was influenced significantly at different stages of harvest, while the effect of different nitrogen levels and their interaction was not statistically traceable. The crop harvested at different intervals was found significant. The highest available phosphorus per hectare (29.1 kg) was found in crop harvested at 90 DAS (H₁) and the lowest (24.1 kg) was recorded in crop harvested at 150 DAS (H₄). The highest available potassium per hectare (364 kg) was registered in crop harvested at 90 DAS (H₁) and the lowest available potassium per hectare (301 kg) was found in crop harvested 150 DAS (H₄).

Harvest at different stages along with application of different dose of nitrogen recorded variation in the soil available nitrogen. Increase in nitrogen application recorded increase in soil available nitrogen. Whereas, the phosphorus and potassium content decreased significantly with subsequent increases in the age of the plant. This may be due to higher phosphorus absorption ability of the shoots and roots during accumulation of secondary metabolites in the roots. These results in accordance with the findings of Guruprasad (2007)^[3] in ashwagandha, Ganapathy *et al.* (2011)^[2] in banana.

Table 1: Major nutrients uptake (kg ha⁻¹) by ashwagandha as influenced by nitrogen levels and harvesting stages

Treatments	Nitrogen uptake (kg ha ⁻¹)					Phosphorus uptake (kg ha ⁻¹)					Potassium uptake (kg ha ⁻¹)				
	H ₁	H ₂	H ₃	H ₄	Mean	H ₁	H ₂	H ₃	H ₄	Mean	H ₁	H ₂	H ₃	H ₄	Mean
N ₀	75.3	98.1	103.1	122.8	99.8	11.75	15.32	17.75	19.40	16.06	42.1	62.1	68.8	90.6	65.9
N ₁	106.8	117.6	126.7	165.2	129.1	12.95	15.24	20.65	22.39	17.81	62.2	73.9	85.4	120.3	85.5
N ₂	144.6	159.8	165.7	196.5	166.8	19.81	22.83	25.48	26.29	23.60	98.4	111.6	125.6	147.6	119.3
N ₃	178.5	176.8	187.1	197.0	184.7	19.91	22.25	23.73	24.88	22.69	83.2	102.8	109.2	141.5	110.7
Mean	126.3	138.1	145.6	170.4	-	16.10	18.91	21.90	23.24	-	71.5	87.6	97.3	125.0	-
	S.Em.±		CD at 5%			S.Em.±		CD at 5%			S.Em.±		S.Em.±		
N	1.007		3.486			2.386		8.257			1.44		1.51		
H	1.830		5.342			2.076		6.059			1.39		0.93		
H at same level of N	3.660		10.68			4.151		12.118			2.78		1.85		
N at same or different level of H	3.326		9.71			4.315		12.595			2.80		2.20		

Nitrogen levelsN₀: 0 kg ha⁻¹N₁: 20 kg ha⁻¹N₂: 40 kg ha⁻¹N₃: 60 kg ha⁻¹**Harvesting stages**H₁: 90 DASH₂: 110 DASH₃: 130 DASH₄: 150 DAS

DAS: Days after sowing

NS: Non significant

Table 2: Soil available nutrients (kg ha⁻¹) after harvest of ashwagandha as influenced by nitrogen levels and harvesting

Treatments	Nitrogen (kg ha ⁻¹)					Phosphorus (kg ha ⁻¹)					Potassium (kg ha ⁻¹)				
	H ₁	H ₂	H ₃	H ₄	Mean	H ₁	H ₂	H ₃	H ₄	Mean	H ₁	H ₂	H ₃	H ₄	Mean
N ₀	175	142	130	124	143	29.4	28.2	25.0	24.0	26.6	367	352	313	300	333
N ₁	201	185	162	156	176	29.8	27.9	25.0	24.0	26.7	373	349	312	300	334
N ₂	226	211	208	205	212	28.3	27.3	25.4	24.3	26.3	353	341	317	304	329
N ₃	248	232	228	225	234	29.0	28.1	24.4	24.1	26.4	363	351	305	302	330
Mean	213	193	182	177	-	29.1	27.9	24.9	24.1	-	364	348	312	301	-
	S.Em.±		CD at 5%			S.Em.±		CD at 5%			S.Em.±		S.Em.±		
N	5.78		20.01			6.25		21.6502			6.00		0.24		
H	3.74		10.93			4.10		11.99			3.92		0.15		
H at same level of N	7.49		21.86			8.21		23.99			7.85		0.31		
N at same or different level of H	8.69		25.36			9.47		27.66			9.07		0.36		

Nitrogen levelsN₀: 0 kg ha⁻¹N₁: 20 kg ha⁻¹N₂: 40 kg ha⁻¹N₃: 60 kg ha⁻¹**Harvesting stages**H₁: 90 DASH₂: 110 DASH₃: 130 DASH₄: 150 DAS

DAS: Days after sowing

NS: Non significant

Conclusion

Nutrient uptake by the plant was significantly influenced by the different nitrogen levels and stages of harvest. Highest nitrogen and potassium uptake was recorded in crop supplied with 40 kg N ha⁻¹ and harvested at 150 DAS. Whereas, phosphorus was found non significant with the combination effect of nitrogen levels and harvesting stages. Whereas, Available nutrients in the soil after harvest of the crop was significantly influenced by the different nitrogen levels and stages of harvest. Soil available nitrogen was recorded higher in the treatment wherein crop supplied with 60 kg N ha⁻¹ and harvested at 90 DAS. Soil available phosphorus and potassium did not show any significant difference. Application of 40 kg N ha⁻¹ and harvested at 150 DAS resulted significantly superior in effective nutrient utilization for better growth and yield.

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