The Pharma Innovation Journal 2022; 11(7): 1272-1276

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 1272-1276

www.thepharmajournal.com
Received: 16-05-2022
Accepted: 29-06-2022

Hemalatha KJ
Scientist, Department of Horticulture, ICAR-KVK, Raichur, Karnataka, India

Kattimani KN
Honorable Vice Chancellor, University of Agricultural Sciences, Raichur, Karnataka, India

Kurubar AR
Professor and Head, UAS, Raichur Karnataka, India

Ramesh G
Assistant Professor, UAS, Raichur Karnataka, India

Umesh MR
Assistant Professor, UAS, Raichur Karnataka, India

Amaregouda
Professor and Head, UAS, Raichur Karnataka, India

Corresponding Author:
Hemalatha KJ
Scientist, Department of Horticulture, ICAR-KVK, Raichur, Karnataka, India

Standardization of nitrogen level and harvesting stage to enhance the growth, yield and quality in Ashwagandha [*Withania somnifera* (L.) Dunal) in the north-eastern dry zone of Karnataka

Hemalatha KJ, Kattimani KN, Kurubar AR, Ramesh G, Umesh MR and Amaregouda

Abstract
The field experiment was carried out at Krishi Vigyan Kendra, University of Agricultural Sciences, Raichur, Karnataka in medium black clayey soil during 2019-2020 to study the "Standardization of nitrogen level and harvesting stage to enhance the growth, yield and quality in Ashwagandha [*Withania somnifera* (L.) Dunal) in the North-Eastern Dry Zone of Karnataka". Experiment was laid out in split plot design with treatment combinations. The main plot consists of four nitrogen levels (N) *viz.*, N_0: 0 kg N ha, N_1: 20 kg N ha, N_2: 40 kg N ha and N_3: 60 kg N ha. Whereas, sub plot consists of four different stages of harvest (H) *viz.*, H_1: 90 DAS, H_2: 110 DAS, H_3: 130 DAS and H_4: 150 DAS. The growth, yield and quality parameters were significantly influenced and varied by the combination effect of different nitrogen levels and harvesting stages. The highest plant height (80.17 cm) was recorded with the application of 60 kg N ha^{-1} and harvested at 150 DAS. Whereas, the highest specific leaf area (304.3 cm^2 g^{-1}), LAI (3.39), RGR (0.59 g g^{-1} day^{-1}), CGR (0.130 g cm^{-2} day^{-1}) and NAR (5.28 g dm^{-2} day^{-1}) was recorded with 60 kg N ha^{-1} harvested at 110 DAS. The highest fresh root (13.01 q ha^{-1}), dry root yield (7.27 q ha^{-1}), seed yield (3.47 q ha^{-1}), root length (27.47 cm), root diameter (4.81 mm) and total alkaloid (1.86%) content was recorded with the application of 40 kg N ha^{-1} and harvested at 150 DAS (N_2H_4). Whereas, highest starch (7.98%) content was reported in the crop supplied with 60 kg N ha^{-1} and harvested at 90 DAS.

Keywords: Ashwagandha, north-eastern dry zone, nitrogen, harvesting stage

Introduction
Medicinal plants are tremendous source of raw material for the modern drug industry. Since time immemorial, plants have been extensively exploited for their therapeutic property. The area under medicinal and aromatic crops has increased over the years with the annual growth rate of 1.12 *per cent* per annum. Among the medicinal plants, ashwagandha is having highest share (61.65%) followed by amla (9.46%), sandalwood (9.41%) and other medicinal and aromatic crops. The plant ashwagandha (*Withania somnifera* L. Dunal) is popularly known as winter cherry or Indian ginseng and is recognized as an important medicinal plant in traditional system of medicine for centuries. The Sanskrit name "ashwa" meaning horse and "gandha" meaning smelling was given to this plant due to the smell of the roots resembling a sweating horse (Naveen, 2018). Karnataka is one of the immensely potential state for the cultivation of medicinal plants as it is blessed with a wide range of climatic conditions and the tropical forests of Western Ghats and deciduous forests of Deccan plateau which are rich in medicinal plants with more than 2500 species in its biodiversity (Shilpa *et al.*, 2018) [14]. Cultivation of ashwagandha is gaining popularity among farmers in north eastern dry zone of Karnataka.
Ashwagandha being a solanaceous crop requires nitrogen in optimum dose as it is an important component of many structural, genetic and metabolic activities in plant cell. Deficiency of nitrogen may limit the crop growth, chlorophyll content and production of secondary metabolites. Stage of harvest may vary from region to region depending on the soil status and climatic conditions (Anon., 2015) [14]. Delay in harvest may leads to increase the fiber content in the roots which is not desirable attribute to determine the quality of the roots. Hence, stage harvest is most important factor to obtain good quality end product. Therefore, the present study was carried out on "Standardization of nitrogen level and harvesting stage to enhance the growth, yield and quality in Ashwagandha [*Withania somnifera* (L.) Dunal) in the

North-Eastern Dry Zone of Karnataka" in medium black clayey soil during 2019-2020 in University of Agricultural Sciences, Raichur, Karnataka, India.

Material and Methods

The field experiment was carried out at ICAR-Krishi Vigyan Kendra, Raichur, Karnataka to Standardization of nitrogen level and harvesting stage to enhance the growth, yield and quality in Ashwagandha [*Withania somnifera* (L.) Dunal) under North-Eastern Dry Zone of Karnataka. The climate of Raichur is semi-arid characterised by extremes of temperature in summer, with low rainfall and moderate relative humidity. The soil of experimental field was clayey loam in texture with 7.9 pH, 0.35 dS/m EC and 0.53% organic carbon. Soil analysis revealed that available nitrogen was low (215 kg/ha) whereas available Phosphorus is medium (28.5 kg/ha) and potassium is medium (389 kg/ha) were in range.

Ashwagandha variety Jawahar Asgandh-20 has been used in the experiment. As the seeds are light in weight, which was mixed with the sand at 1:2 proportion and sown in lines of 30 cm apart to a depth of 2-3 cm on 16th of August 2019. Experiment was laid out in split plot design with treatment combinations. The main plot consists of four nitrogen levels (N) *viz.*, N_0: 0 kg N ha, N_1: 20 kg N ha, N_2: 40 kg N ha and N_3: 60 kg N ha. Whereas, sub plot consists of four different stages of harvest (H) *viz.*, H_1: 90 DAS, H_2: 110 DAS, H_3: 130 DAS and H_4: 150 DAS. The seedlings were thinned at 30 DAS and only one healthy seedling per hill was retained at a spacing of 10 cm between the plants.

The observation on growth (plant height, number of branches, specific leaf area and leaf area index) and yield parameters (total dry matter accumulation, fresh root yield, dry root yield, seed yield) were recorded at different stages of harvest. Quality parameters (root length, root girth, starch content and total alkaloid content) were recorded after harvest of the crop at different stage as per the treatment. The data on various observations collected during the period of experimental study were statistically analysed by split plot design outlined by Panse and Sukhatme (1985) [12].

Result and Discussion

Growth Parameters

The plant height (cm) of ashwagandha was significantly influenced by the application of nitrogen at different levels and stages of harvest. The maximum plant height (60.57 cm) was recorded by the application of 60 kg N ha^{-1} (N_3) and minimum plant height (46.01 cm) was recorded in plants grown without nitrogen (N_0) application at harvest. With respect to different harvesting stages, the maximum plant height (72.20 cm) was recorded in crop harvested at 150 DAS (H_4) and it was recorded minimum (39.65 cm) in the crop harvested at 90 DAS (H_1) at harvest. The interaction effect of different nitrogen levels and stages of harvest recorded significantly highest plant height (80.17 cm) as the crop was supplied with 60 kg N ha^{-1} and harvested at 150 DAS (N_3H_4). Whereas, minimum plant height (30.09 cm) was recorded in plants grown without nitrogen application and harvested at 90 DAS (N_0H_1). This might be due to increase in plant height during peak vegetative growth stage and initiation of reproductive growth stage thereafter might hinder the plant height. These results were in accordance with the finding of Nichapur (2010) [11], who reported that application of optimum level of nitrogen (30 kg N ha^{-1}) triggered the growth of meristematic tissues by potential cell elongation which increased the plant height (69.97 cm) in ashwagandha in northeastern transition zone of Karnataka. Manohar *et al.* (2012) [8] and Aladakatti *et al.* (2012) [1] both have reported higher plant height in ashwagandha with the supply of 40 kg N ha^{-1} along with P and K.

Increase in number of branches was recorded considerably with graded levels of nitrogen. Maximum number of branches (7.66) was recorded with the application 60 kg N ha^{-1} (N_3) followed by application of 40 kg N ha^{-1} (7.65) and minimum number of branches (4.76) was recorded in plants grown without nitrogen application (N_0) at harvest. Crop harvested at different stages were also significantly influenced on the number of branches per plant in ashwagandha. The highest number of branches (7.18) was recorded in crop harvested at 150 DAS (H_4), which was on par with crop harvested at 130 DAS (7.12) and lowest (5.46) at 90 DAS. The interaction effect of nitrogen and stage of harvest influenced significantly on number of branches per plant in ashwagandha. Maximum number of branches (8.80) was recorded in plants supplied with 40 kg N ha^{-1} and harvested at 150 DAS (N_2H_4). While lowest number of branches (3.88) was recorded in plants grown without nitrogen application and harvested at 90 DAS (N_0H_1). Supply of optimum nitrogen level might have enhanced the plant height, internodal length and number of branches per plant. These results were in similarities with the findings of Aladakatti *et al.* (2012) [1] and Manohar *et al.* (2012) [8] who reported higher number of branches per plant (4.95) with the application of 40 kg N ha^{-1} in ashwagandha.

Maximum SLA and LAI was recorded (304.31 cm^2 plant^{-1} and 3.39) with the application of 60 kg N ha^{-1} and harvested at 110 DAS. The result of the present data recorded that every 20 kg increase in application of nitrogen from 0 to 20, 40 and 60 kg ha^{-1} recorded 15.43%, 2.54% and 1.38% increase in SLA. With respect to different harvesting stages, highest SLA and LAI (289.4 cm^2 plant^{-1} and 3.11) was recorded at 110 DAS as compared to 150 DAS (265.8 cm^2 plant^{-1} and 2.7). Maximum SLA and LAI was recorded during peak vegetative growth stage due to retention of maximum number of leaves per plant. As progress in the age of the plant, due to physiological changes leaves were subjected to senescence causing reduction in SLA at 150 DAS.

Table 1: Plant height, number of branches, specific leaf area and leaf area index of ashwagandha (*Withania somnifera* L.) at harvest as influenced by nitrogen levels and harvesting stages

Treatments	Plant height (cm)					Number of branches					Specific leaf area (cm^2 plant^{-1})					Leaf area index				
	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean
H_1	30.09	40.23	42.96	45.30	39.65	3.88	5.06	5.80	7.11	5.46	273.0	286.1	281.0	298.2	286.1	2.42	3.29	3.21	3.16	3.06
H_2	39.84	45.70	51.63	53.98	47.79	4.56	6.35	7.76	7.84	6.63	267.1	295.9	296.2	304.3	289.4	2.91	2.81	3.33	3.39	3.11
H_3	52.16	59.90	61.58	62.82	59.11	4.90	6.92	8.25	7.82	7.12	252.2	254.9	291.0	295.1	273.3	3.06	2.82	3.00	3.06	2.99
H_4	61.97	66.56	80.10	80.17	72.20	5.71	6.93	8.80	7.87	7.18	190.1	276.5	294.6	301.9	265.8	2.71	2.64	2.76	2.70	2.70
Mean	46.01	53.10	59.07	60.57	-	4.76	6.31	7.65	7.66	-	245.6	283.5	290.7	294.7	-	2.81	2.89	3.06	3.10	-

	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
N	0.43	1.49	0.14	0.48	6.79	23.48	0.07	0.25
H	0.78	2.28	0.13	0.38	6.26	18.26	0.05	0.16
H at same level of N	1.56	4.56	0.26	0.75	12.51	36.52	0.11	0.31
N at same or different level of H	1.42	4.14	0.26	0.77	12.78	37.31	0.12	0.35

Table 2: Total dry matter accumulation, fresh root yield, dry root yield and seed yield of ashwagandha (*Withania somnifera* L.) as influenced by nitrogen levels and harvesting stages

Treatments	Dry matter accumulation (g plant^{-1})					Fresh root yield (kg ha^{-1})					Dry root yield (kg ha^{-1})					Seed yield (kg ha^{-1})				
	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean
H_1	48.14	63.74	83.45	96.49	72.96	412	441	509	490	463	224	239	273	278	254	38.4	46.5	50.1	43.2	44.6
H_2	64.37	73.11	95.31	106.49	84.82	531	593	781	669	643	292	321	372	433	354	130.6	144.2	158.9	147.6	145.3
H_3	68.73	82.61	99.59	112.16	90.77	995	1106	1239	1256	1149	549	609	692	679	632	227.8	248.3	313.9	311.7	275.4
H_4	83.27	107.97	123.64	126.55	112.61	1065	1151	1301	1248	1191	584	634	727	683	657	263.3	320.6	347.2	338.3	317.4
Mean	66.13	81.86	105.00	110.17	-	751	823	944	929	-	412	451	519	516	-	165.0	189.9	217.5	210.2	-
	S.Em.±			CD at 5%		S.Em.±			CD at 5%		S.Em.±			CD at 5%		S.Em.±			CD at 5%	
N	0.81			2.80		12.81			44.32		1.43			4.93		3.07			10.63	
H	0.90			2.63		11.34			33.11		1.46			4.26		4.70			13.73	
H at same level of N	1.80			5.26		22.69			66.22		2.92			8.53		9.41			27.46	
N at same or different level of H	1.76			5.13		23.45			68.46		2.90			8.48		8.71			25.41	

Table 3: Root length, root girth, total alkaloid content and starch content of ashwagandha (*Withania somnifera* L.) roots as influenced by nitrogen levels and harvesting stages

Treatments	Root length (cm)					Root girth (cm)					Total alkaloid (%)					Starch (%)				
	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean	N_0	N_1	N_2	N_3	Mean
H_1	12.18	13.67	15.93	14.45	14.06	1.90	2.40	2.87	3.15	2.58	0.93	1.00	1.04	1.04	1.00	6.22	7.01	7.06	7.98	7.06
H_2	14.89	16.88	23.44	21.01	19.06	2.37	2.94	3.68	3.63	3.15	1.05	1.14	1.20	1.20	1.15	4.77	5.15	5.55	5.64	5.28
H_3	18.11	20.49	27.13	26.84	23.14	3.75	4.11	4.57	4.17	4.21	1.21	1.36	1.52	1.41	1.38	4.30	4.25	4.46	4.62	4.41
H_4	19.50	21.05	27.47	27.26	23.82	3.92	4.28	4.81	4.38	4.36	1.33	1.58	1.86	1.48	1.56	3.64	3.64	3.99	3.05	3.58
Mean	16.17	18.02	23.37	22.51	-	2.98	3.43	3.98	3.83	-	1.13	1.27	1.40	1.28	-	4.73	5.01	5.26	5.32	-
	S.Em.±			CD at 5%		S.Em.±			CD at 5%		S.Em.±			CD at 5%		S.Em.±			CD at 5%	
N	0.14			0.50		0.02			0.08		0.003			0.012		0.039			0.135	
H	0.17			0.49		0.03			0.09		0.004			0.011		0.111			0.324	
H at same level of N	0.34			0.98		0.06			0.18		0.007			0.022		0.222			0.649	
N at same or different level of H	0.32			0.95		0.06			0.17		0.007			0.021		0.196			0.573	

Yield Parameters

Application of 60 kg N ha^{-1} (N_3) recorded significantly higher dry matter accumulation per plant at harvest (110.17 g) followed by application of 40 kg N ha^{-1} (N_2) (105.0 g) at harvest. Whereas, lowest dry matter accumulation per plant (66.13 g) was recorded without nitrogen (N_0) application. Similarly, different stage of harvest also influenced significantly and found highest dry matter production per plant (112.61 g) at 150 DAS (H_4). However, crop harvested at 90 DAS (H_1) recorded lowest dry matter accumulation per plant (72.96 g). The interaction of nitrogen levels and stage of harvest recorded significant highest dry matter accumulation per plant (126.55 g) with 60 kg N ha^{-1} harvested at 150 DAS (N_3H_4). The lowest dry matter accumulation per plant (48.14 g) was recorded in plants grown without nitrogen application and harvested at 90 DAS (N_0H_1). This may be due to elevated nitrogen supply which boosts dry matter accumulation through production of maximum plant height, higher number of branches and more number of leaves per plant during vegetative growth stage. Further, this helps with higher accumulation of starch, proteins, secondary metabolites and fats in the roots and stem, which enhances the thickening of the stem and root. These results found in similar with the observations recorded by Mohammad *et al.* (2015). The maximum dry weight per plant (93.21 g) was reported with the application of 200 kg urea ha^{-1} in chamomile. Raghuveer (2019) [11] also recorded highest dry matter production per plant (48.92 g) at 120 DAS with application of 35 kg N ha^{-1} in ashwagandha.

Fresh root yield and dry root yield influenced significantly by the different nitrogen levels, stages harvest and its interaction effect. Application of 40 kg N ha^{-1} (N_2) recorded highest fresh root yield per hectare (944 kg and 519 kg) and minimum (751 kg and 412 kg) was recorded in crop grown without nitrogen (N_0). The crop harvested at different stages were significantly affected fresh root yield per hectare. Higher fresh root yield and dry root yield per hectare (1191 kg and 657 kg) was obtained in crop harvested at 150 DAS (H_4) and lowest in

crop harvested at 90 DAS (463 kg and 254 kg). its interaction effect influenced significantly and highest fresh root yield and dry root yield per hectare (1301 kg and 727 kg) was recorded with the application of 40 kg N ha^{-1} and harvested at 150 DAS (N_2H_4) as compared to without nitrogen application and harvested at 90 DAS (N_0H_1) (412 kg and 224 kg). The result obtained might be due to accumulation of more metabolites produced maximum starch content in the roots at optimum nitrogen level, however, the increase in nitrogen level caused the conversion of starch to fibre which reduced the fresh root yield. Maximum root length and higher root girth was achieved as the crop ages and it is found that 150 DAS was the ideal stage to harvest the crop for maximum fresh root yield and dry root yield. Similar results were also found with the application of nitrogen 30:20:20 kg NPK ha^{-1} recorded maximum fresh root yield (795 kg ha^{-1}) at 150 DAS in ashwagandha as compared to without nitrogen application (Behera *et al.*, 2015) [4].

The maximum seed yield per hectare (348.2 kg) was recorded with supply of 40 kg N ha^{-1} and harvested at 150 DAS. Lowest seed yield was recorded in plants grown without nitrogen application and harvested at 90 DAS (38.4 kg). The increase in seed yield (15.09%, 31.81% and 27.39%) was recorded with increase in nitrogen level (20 kg, 40 kg and 60 kg ha^{-1}). The reduction of seed yield by 3.47% was recorded with increase in nitrogen level from 40 kg to 60 kg N ha^{-1}. This may be due to enhanced foliage proliferation with higher dose of nitrogen which ultimately suppressed the flower differentiation. Optimum level of nitrogen stimulated more flower buds, fruit set and higher seed set as prolong the harvesting stages. Crop harvested at 90 DAS and 110 DAS was produced very minimum quantity of seed yield per hectare as the stage of harvest was found to be peak flower initiation and fruit setting stage. With progress in age of the plant, maximum fruit filling and seed thickening enhanced the seed yield at 150 DAS. The findings were similar to that of the results obtained by Raghuveer (2011) and Chandranath (2006) [5].

Quality Parameters

Different nitrogen levels, stage of harvest and their interaction showed significant effect on root length and root girth of ashwagandha. Significantly highest root length and root girth (23.37 cm and 3.98 cm) was recorded with the application 40 kg N ha^{-1} (N_3) which was on par (22.51 cm and 3.83 cm) with the application of 60 kg N ha^{-1} (N_2). The least root length and root girth (16.17 cm and 2.98 cm) was recorded in plants grown in without nitrogen (N_0) application. Similarly, stage of harvest influenced significantly and recorded highest root length and root girth (23.82 cm and 4.36 cm) in crop harvested at 150 DAS. The interaction of application of nitrogen with stage of harvest recorded highest root length and girth (27.47 cm and 4.81 cm) was recorded with 40 kg N ha^{-1} harvested at 150 DAS (N_2H_4) and the least root length and girth (12.18 cm and 1.90 cm) was recorded in without nitrogen and harvested at 90 DAS (N_0H_1). The application of excess amount of fertilizers might caused burning and death of the root hairs, affecting negatively on root growth by inhibiting the elongation and enlargement of the root cells. These findings were in accordance with the results of Guruprasad (2007) [7], Manohar *et al.* (2012) [8] and Wankhade *et al.* (2010) [15].

Starch is the most essential source in response to determine the production of secondary metabolites. The starch content (%) was found maximum (7.98%) in plants supplied with 60 kg N ha^{-1} and harvested at 90 DAS. Whereas, the reduction in starch content was recorded to maximum extent (3.05%) as the harvesting stage prolonged upto 150 DAS. This might be due to fact that the starch is inversely proportion to total withanolide content. The starch content started to reduce as the withanolide content increased in the roots. Application of optimum level of nitrogen (40 kg N ha^{-1}) increased the total alkaloid content (1.40%). Different stages of harvest also significantly influenced the quality of ashwagandha roots and found highest total alkaloid content (1.56%) at 150 DAS as compared to 130 DAS and 110 DAS. Plants supplied with 40 kg N ha^{-1} and harvested at 150 DAS has shown highest total alkaloid content (1.86%) in root. This might be because of good yield attributes *viz.*, primary roots, root length, root girth added that resulted higher alkaloid content in the plants. The total alkaloid content was found to decrease with increased nitrogen levels and harvesting stage. These results were in co-ordinance with the findings of Atul *et al.* (2012), Wankhade *et al.* (2010) [15] and Ewon *et al.* (2018) [6].

Summary and Conclusion

Application of 60 kg N ha^{-1} and harvested at 150 DAS in ashwagandha recorded maximum plant height (80.17 cm) and number of branches (8.80). Whereas, the highest specific leaf area (304.3 cm^2 g^{-1}) and LAI (3.39) was recorded with 60 kg N ha^{-1} harvested at 110 DAS. The yield parameters recorded highest *i.e.* total dry matter accumulation (126.55 g $plant^{-1}$), fresh root (13.01 q ha^{-1}), dry root yield (7.27 q ha^{-1}), seed yield (3.47 q ha^{-1}), as well as quality parameter like root length (27.47 cm), root girth (4.81 cm) and total alkaloid (1.86%) content was recorded with the application of 40 kg N ha^{-1} and harvested at 150 DAS. From the present investigation, it is concluded that the application of 40 kg N ha^{-1} is optimum dose and 150 DAS is the best harvesting stage to obtain maximum root yield, seed yield, high secondary metabolites in ashwagandha. Optimum supply of nitrogen along with appropriate harvesting stage is economically feasible to get maximum quality yield to the growers of North eastern dry zone of Karnataka.

References

1. Aladakatti YR, Palled YB, Chetti MB, Halikatti SI, Alagundagi SC, Patil PL. Effect of nitrogen, phosphorus and potassium levels on growth and yield of stevia (*Stevia rebaudiana* Bertoni.). Karnataka J Agric. Sci. 2012;25(1):25-29.
2. Anonymous. Good agricultural practices for ashwagandha. Extension Bulletin, ICAR-Directorate of medicinal and aromatic plants research, Anand, 2015, pg.03.
3. Atul Kumar Shrivastava, Upadhyay VB, Gautam DS, Sarvade S, Sahu RK. Effect of integrated nutrient management on growth and productivity of *Withania somnifera* (L.) Dunal in Kymore Olateau and Satpura hills of Madhya Pradesh, India. Arch. Agr. Environ. Sci. 2018;3(2):202-208.
4. Behera MS, Mahapatra PK, Singandhupe RB, Kundu D, Kannan K. Effect of drip fertigation on soil moisture use dynamics, nutrient uptake and productivity of Ashwagandha (*Withania somnifera* L.), J. Soil and Water Conservation. 2015;14(1):41-48.

5. Chandranath HT. Investigations on nutrient management and planting geometry in companion cropping of sunflower (*Helianthus annuus*) and ashwagandha (*Withania somnifera* Dunal). Ph.D. Thesis, College of Agriculture, Dharwad, 2006.
6. Ewon Kaliyadasa, Lalith Jayasinghe, Sriyani Peiris. Yield and phytochemical attributes of ashwagandha (*Withania somnifera* Dunal) tubers as affected by source of nutrients. J. Adv. Agri. Tech. 2018;5(2):144-148.
7. Guruprasad. Influence of organic manures on growth and yield in ashwagandha (*Withania somnifera* Dunal). M.Sc. Thesis, College of Agriculture, Navile, Shimoga, 2007.
8. Manohar S, Choudhary MR, Yadav BL, Dadheech S, Singh SP. Analyzing the efficacy of organic and inorganic sources of nitrogen and phosphorus on growth of ashwagandha (*Withania somnifera* Dunal.). J. Hort. Sci. 2012;7(2):161-165.
9. Mohammad Reza Has Seyed Hadi, Mohsen Abarghooel Fallah, Mohammad Taghi Darzi. Influence of nitrogen fertilizer and vermicompost application on flower yield and essential oil of chamomile (*Matricaria Chamomile* L.). J. Chem. Health Risks. 2015;5(3):235-244.
10. Naveen Gaurav. A Review: Pharmacological and medicinal activity of active compounds of *Withania somnifera*. J. Engr. Tech. 2018;3(2):ISSN (2231-4210).
11. Nichapur Vijaya. Effect of organic manures and inorganic fertilizers on growth, root yield and quality of ashwagandha (*Withania somnifera* Dunal.). M.Sc. (Hort.), Thesis, Kittur Rani Channamma College of Horticulture, Arabhavi, 2010.
12. Panse VG, Sukhatme PV. Statistical methods for agricultural workers IInd enlarged Ed. I.C.A.R., New Delhi, 1985, pp. 135-136.
13. Raghuveer Prasad. Effect of different sowing methods and manuring on growth, bio-chemical traits and yield of ashwagandha (*Withania somnifera* L. Dunal). M.Sc. Thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, 2019.
14. Shilpa P, Chowti, Shreeshail Rudrapur, Naik BK. Conservation, cultivation and utilisation of medicinal and aromatic plants. J Pharm. Phytochem. 2018;3:374-377.
15. Wankhade SG, Gholap SV, Manisha Patil. Harvesting period management for production of quality roots of ashwagandha (*Withania somnifera*.Dunal). Annuals of Pharmacy and Pharmaceutical Sci. 2010;1(2):71-73.