Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP3: 118-121

Ningaraju GK
Ph.D. Scholar Department of Agronomy, UAS, GKVK, Bengaluru, India

Praveenakumar R
Ph.D. Scholar Department of Horticulture, UAS, GKVK, Bengaluru, India

Gopinath G
Professor Department of Horticulture, UAS, GKVK, Bengaluru, India

Correspondence
Ningaraju GK
Ph.D. Scholar Department of Agronomy, UAS, GKVK, Bengaluru, India

National conference on "Conservation, Cultivation and Utilization of medicinal and Aromatic plants"
(College of Horticulture, Mudigere Karnataka, 2018)

Integrated nutrient management in Ashwagandha (*Withania somnifera*): A Review

Ningaraju GK, Praveenakumar R and Gopinath G

Abstract
Withania somnifera commonly called as Ashwagandha is a widely used medicinal herb in Ayurveda. It is considered to be a Rasayana herb, an adaptogen, and is commonly referred to as 'Indian ginseng'. It is one of the most important medicinal plant coined with two words *viz*., Ashwini and Gandha. Ashwini means horse and Gandha means power. Although an important medicinal plant, it is still seen growing on waste and marginal lands, with little or no manures and fertilizers. Use of organic manures, biofertilizers and inorganic fertilizers has assumed great importance for sustainable production and for maintaining soil health. These not only supply macro- and micro-nutrients to the crop but also improve the physical, chemical and biological properties of the soil, leading to good crop production. The advantage of combining inorganic and organic sources of nutrients generally results in better use of each component which is responsible for crop growth and development. In this paper, the literatures pertaining to the different aspects of integrated nutrient management are reviewed.

Keywords: ashwagandha, growth, organic manures, bio fertilizers, NPK, yield

Introduction
Ashwagandha (*Withania somnifera*. Dunal) is an important medicinal plant, of the family Solanaceae. It is a perennial branched, evergreen shrub of 30-120 cm height. It is native to the Mediterranean region and is also found growing naturally in forests, particularly, in arid and semiarid parts of the world. It is also known as 'Indian Ginseng' because of similarity between the properties of Ashwagandha roots and restorative properties of Ginseng roots. Distribution of this plant differs in different regions in India. Most commonly its roots and occasionally leaf and seed are used in Ayurvedic and Unani medicines. It has significant value in the pharmacological activity due to the presence of alkaloids in roots. Roots contain several pyrazole alkaloids namely withasomnine and steroldal, withaferin A and withanolides (Dastur, 1970) [2]. There is a growing concern about adverse effect of use of chemical fertilizers and chemical pesticides. Looking at the ill effects of such chemicals, it was considered of interest to use organic manures (farmyard manure, oil cakes and vermicompost) and biofertilizers. The interactive advantage of combining inorganic and organic sources of nutrients generally results in better use of each component (Manna *et al*, 2005) [10].

Effect of integrated nutrient management on growth, root yield and quality of ashwagandha
Maheshwari *et al.* (2000) [9] in a 2-year yield study the highest dry-root yield, maximum net return and higher benefit: cost ratio of ashwagandha (*Withania somnifera* L. Dunal) were recorded by applying 2.5 tonnes/ ha farmyard manure along with 12.5 kg N + 25 kg P_2O_5/ha. Under rainfed condition in a shallow black soil. Application of 5 t farmyard manure ha^{-1} was also found suitable for increasing the dry-root yield. Cultivar 'JA 20' performed very well compared with 'JA 134'.
Panchabhai *et al.* (2005) [14] evaluated the effect of nitrogen and phosphorus on growth and seed yield of Ashwagandha (*Withania somnifera* L.) during kharif season. The result indicated that the vegetative growth of Ashwagandha in term of plant height and biomass were increased with higher level of nitrogen and lower levels of phosphorus (50 kg N and 25 kg P_2O_5 ha^{-1}) significantly highest seed yield of Ashwagandha (251.28 kg ha^{-1}) were obtained with the application of 50 kg N and 25 kg P_2O_5 /ha.

Organic manures improve the physical properties of soils, which is very beneficial for plants. Such manures increase the humus content of soils and as a consequence of improved soil texture, structure, consequently the water holding capacity of sandy soils increase and drainage of clayey soil improve. In an experiment in Madhya Pradesh, India to study the effect of nitrogen (0 20, 40 and 60 kg ha^{-1}) and farmyard manure (FYM at 10 t ha^{-1}) on some physiological, biochemical parameters and quality of root of medicinal plant ashwagandha (*Withania somnifera*) at pre-flowering and post-flowering stages. Significant differences in pigment content (chlorophyll and carotenoids) were observed in both pre and post flowering stages. The total phenol and ortho-dihydric phenol content decreased with the application of nitrogen in pre-flowering stage, but increased with the application of nitrogen at post-flowering stage. The quality of root based on the alkaloid content was found to be better at low nitrogen level (NO and N_2O) and FYM. However, the root yield was maximum 20 kg N ha^{-1} (Ajay *et al*., 2005).

A pot experiment was conducted in Aligarh, Uttar Pradesh, India to evaluate the effect of nitrogen fertilizer application on the physiomorphological characteristics of *Withania somnifera*. Seeds were sown directly in 30 cm diameter earthen pots and the soil was treated with 4 levels of nitrogen (0, 30, 60 and 90 kg/ha) as urea. Only one seedling was maintained in each pot after 4 weeks. All nitrogen treatments were effective in enhancing all physiomorphological parameters in comparison with the control. However, nitrogen at 90 kg ha^{-1} recorded the highest values for growth, chlorophyll content, nitrate reductase activity, and leaf protein and nitrogen contents (Singh *et al*., 2005) [10].

Khanna *et al*. (2006) [7] conducted a field experiment in Jammu, India, during 2003-04 with 2 biofertilizers (*Azotobacter chroococcum* and *Azospirillum brasilense*) applied as seed treatment at 0.5 kg/ha to *Withania somnifera*. Azospirillumbrasilense had beneficial effects morphologically on root and shoot biomass and biochemically on assimilation of total amino acids, soluble protein, starch and crude fiber. It recorded higher root fresh and dry yields (74.8 and 25.6 q ha^{-1}, respectively) than *Azotobacter chroococcum* (73.7 and 24.7 q ha^{-1}, respectively).

Organic and inorganic fertilizers affects the performance of *Withania somnifera.* The effects of organic and inorganic fertilizers on the performance of ashwagandha were studied during the *kharif* of 2003-04 and 2004-05 in Mandsaur, Madhya Pradesh, India. The treatments consisted of: farmyard manure (FYM; 5 t ha^{-1}), poultry manure (PM; 5 t ha^{-1}), goat manure (5 t ha^{-1}) or vermicompost (5 t ha^{-1}), singly or in combination with 50 per cent of the recommended NPK rates. The treatments had no significant effects on plant height and plant density, but enhanced the number of branches per plant, root length, root diameter, quality and yield over the control. The highest mean number of branches per plant (6.2) was obtained with 50 per cent RDF and VMC + 50 per cent RDF. The mean root length (28.0 cm), diameter (0.93 cm), seed yield (930 kg ha^{-1}), dry root yield (643 kg ha^{-1}) and net profit (Rs. 35,380 ha^{-1}) were greatest with vermicompost. The highest quality grade was obtained with PM, VMC and PM + 50 per cent RDF. The application of 50 per cent RDF resulted in the highest benefit cost ratio (3.47) (Kulmi *et al*., 2006) [8].

The rhizosphere of inoculated plants recorded rhizobacterial population in a pot culture experiment in Coimbatore, Tamil Nadu, India to determine the effect of combined inoculation of rhizosphere bacteria, viz., Azospirillumlipoferum, Azotobacter, Bacillus, phosphate solubilizing bacteria and Pseudomonas fluorescens on the growth, yield and quality of ashwagandha (*Withania somnifera*). Survival of rhizosphere bacteria was found to be greater in the inoculated plants compared to the uninoculated ones. However, under pot culture conditions, the population of Azospirillum, Azotobacter, Pseudomonas and phosphate solubilizing bacteria increased up to 120 days after inoculation (Gopal *et al*., 2006) [3].

Panchbhai *et al.* (2006) executed a field experiment in Akola, Maharashtra, to evaluate the effect of N and P on root yield and quality of *Withania somnifera* that treatments comprised combinations of N at 0, 25 and 50 kg ha^{-1}; and P at 0, 25, 50 and 75 kg ha^{-1}. Maximum root yields were obtained with N at 50 kg ha^{-1} (825.6 kg ha^{-1}) and P at 25 kg/ha (836.7 kg ha^{-1}). The maximum alkaloid content was obtained with N at 50 kg ha^{-1} (0.44%) and P at 50 kg ha^{-1} (0.42%). More alkaloid content in roots was obtained with the treatment N: P at 50:50 and 50:75 kg ha^{-1} than with other treatments.

Santhi *et al*. (2010) [16] conducted experiment to elucidate the relationship between soil tests and response of ashwagandha to applied fertilizers under Integrated Plant Nutrition System (STCR-IPNS), Using the data on dry root yield, initial soil test values on available NPK, doses of fertilizers and farm yard manure (FYM) applied and NPK uptake. It was found that 77.6, 31.7 and 113.3 kg of N, P_2O_5 and K_2O respectively were required for producing one tonne dry root of ashwagandha. The per cent contribution of nutrients from soil, fertilizer and FYM were 19.03, 31.30 and 23.14 for N; 20.26, 17.30 and 6.38 for P_20_5, 11.08, 62.53 and 30.39 for K_2O respectively.

Kaur *et al.* (2011) [5] studies on twenty seven bacterial strains of both Pseudomonas and Bacillus sp. from the rhizosphere of Ashwagandha were isolated and screened out for phosphate solubilization and production of other types of plant growth promoting activities affecting directly or indirectly. Out of twenty seven strains six strains, three of *Bacillus sp*. (WsNB-2, WsNB-6, and WsNB-13) and three of *Pseudomonas sp*. (WsCP-1, WsCP-5 and WsCP-6) were selected to study the effect of phosphate solubilizing strains on the growth of rooted cutting of Ashwagandha and on other soil parameters like root colonization and phosphorous content of soil before and after the experiment. The selected strains significantly enhanced plant height after two months of plantation. Rhizosphere bacterial population increased significantly, which has resulted in nutrient mobilization and ultimately resulted in enhanced plant growth.

Shrivastava *et al.* (2012) [17] conducted field experiment to evaluate the effect of inorganic and organic fertilizers on *Withania somnifera* seed and root yield was conducted for two cousecutive *kharif* seasons at the research farm of the College of Agriculture, JNKVV, Jabalpur. Fourteen treatments consisting of chemical fertilizer, either alone or in combination with FYM, vermicompost and $ZnSO_4$ were evaluated in a randomized block design. The two year data suggested that application of 40:20:20 kg ha^{-1} $N:P_2O_5:K_2O$ fertilizers along with vermicompost (2.5 t ha^{-1}) and, FYM (5 t ha^{-1})+$ZnSO_4$ (20 kg ha^{-1}) produced maximum root dry matter (612.8 kg ha^{-1}) and seed yield (62.6 kg ha^{-1}). Ashwagandha roots produced in above treatment were also better in quality, containing 0.069% withanolide A, 0.037% withanolide B, 0.065% withaferin-A and 1.40% total alkaloids.

Vajantha *et al.* (2012) [19] conducted 2 years experiment to study the effect of different levels of NPK (0, 50, 100 and 150%), organic manures (castor cake @ 2.5 t ha^{-1} and vermi-compost @ 1 t ha^{-1}), *panchagavya* and bio fertilizers

(*Azospirillum* and phosphorus solubilising bacteria each of 5 kg ha^{-1}) on growth and root yield of Ashwagandha at College Farm, College of Agriculture, Hyderabad. Results indicated that, the highest dry matter production (3314 and 3083 kg ha^{-1} and 6204 and 5101 kg ha^{-1}) and dry root yield (127 and 125 kg ha^{-1} and 348 and 333 kg ha^{-1}, respectively) was recorded with conjunctive use of 150 per cent NPK with castor cake @ 2.5 t ha^{-1}.

Manohar *et al*. (2012) [11] conducted experiment to know the effect of nitrogenous (N) and phosphatic (P) fertilizers at 20 kg ha^{-1} and 40 kg ha^{-1} each, and two levels of farm yard manure (FYM) and vermicompost and combinations thereof, along with control. Results revealed that application of 40 kg ha^{-1} of N and P each as urea and SSP + 2.5 t ha^{-1} vermicompost registered significant values for plant height, number of branches per plant, leaf area, yield attributing traits, root (8.60 q ha^{-1}) and seed yield (85.6 kg ha^{-1}) as well as soil physical properties like organic carbon, hydraulic conductivity and water retention at 33 and 1500 kpa besides the highest B:C ratio (2.57).

Kaushal kumar *et al*. (2013) [6] revealed that application of jatropha cake at 3 t ha^{-1} + 50% RDF + PSB at 2 kg ha^{-1} + Azospirillum at 2 kg ha^{-1} recorded highest plant height (49.9 cm), shoot fresh weight (32.09 g $plant^{-1}$), shoot dry weight (10.41 g $plant^{-1}$), leaf fresh weight (64.91 g $plant^{-1}$), leaf dry weight (13.84 g $plant^{-1}$), leaf area (1193.1 cm^2), root length (24.5 cm), root fresh and dry weight (11.38 and 4.68 g $plant^{-1}$), fresh and dry root yield (2.36 and 0.78 t ha^{-1}) with higher uptake of Nitrogen (95.92 kg ha^{-1}), phosphorus (31.60 kg ha^{-1}) and potassium (100.92 kg ha^{-1}) which is on par with application of vermicompost at 6 t ha^{-1} + 50% RDF +PSB at 2 kg ha^{-1} + Azospirillum 2 kg ha^{-1}.

Vishal Goel and Duhan (2014) [20] studied to know the effect of inorganic source of nutrients alone and in combination with farm yard manure (FYM) on plant growth parameters, root yield and alkaloids yield, status under ashwagandha. The results revealed that, vegetative parameters of ashwagandha (*viz*. plant height, number of primary branches, plant spread and dry weight of shoot) were enhanced significantly with the application of 12.5 mg P_2O_5 kg^{-1} soil, whereas; dry weight of roots was enhanced up to the application level of 25 mg P_2O_5 kg^{-1} soil. FYM at the rate of 12.5 t ha^{-1} in combination with 12.5 mg P_2O_5 kg^{-1} soil significantly improved all the vegetative parameters, whereas, FYM at the rate of 12.5 t ha^{-1} in combination with 25 mg P_2O_5 kg^{-1} soil significantly enhanced the dry weight of the roots (3.92 g), The application of FYM at the rate of 12.5 t ha^{-1} improved the alkaloids yield (mg pot^{-1}) but the significantly highest yield of total alkaloids (17.4 mg pot^{-1}) was found in the treatment combination of 12.5 t FYM ha^{-1} + inorganic-P at the rate of 25 mg P_2O_5 kg^{-1} soil. Nutrients (NPK) uptake by ashwagandha shoot increased significantly with the application level of 12.5 mg P_2O_5 kg^{-1} soil over control whereas in case of ashwagandha roots, higher NPK uptake (86.6, 21.9 and 65.6 mg $plot^{-1}$ N, P_2O_5 and K_2O, respectively) was recorded with FYM at the rate of 12.5 t ha^{-1} + 12.5 mg P_2O_5 kg^{-1} soil over control.

Jitendra Patidar *et al*. (2014) [12] opined that, the maximum plant height (9.60, 31.43, 50.20, 60.57 and 65.90 cm), number of branches per plant (0.0, 3.10, 6.67, 9.71 and 10.78), number of leaves per plant (4.16, 50.53, 82.50, 104.67 and 25.60), leaf area per plant (11.16, 202.31, 600.97, 791.28 and 194.10 cm^2 $plant^{-1}$), leaf biomass (1.42, 2.83, 11.30, 17.41 and 6.89 q ha^{-1}), stem biomass (0.82, 2.05, 9.82, 27.19 and 52.59 q ha^{-1}) and root yield (0.64, 1.24, 4.64, 6.41 and 9.15 q ha^{-1}) of ashwagandha at 30, 60, 90, 120 and at harvest, respectively obtained with the application of 50% NPK + 5 tonnes FYM + PSB + Azotobacter + 5 kg Zn ha^{-1}).

Patil *et al*. (2014) [13] conducted field experiment at the Department of Medicinal and Aromatic Plants, K.R.C. College of Horticulture, Arabhavi, to know the effect of different combinations of organic and chemical fertilizers on ashwagandha. Among different combinations, application of 2 tonnes of FYM + 0.5 tonne of vermicompost + 20:30:20 kg NPK per hectare recorded significantly highest plant height (70.81 cm), number of leaves (96.51), number of branches (8.89), maximum fresh and dry root yield (13.68 q ha^{-1} and 11.09 q ha^{-1} respectively), and maximum benefit cost ratio (4.83).

Integrated nutrient management practices significantly influenced growth, yield and quality parameters of ashwagandha. Significantly higher values of fresh root yield, dry root yield, root length root diameter, seed yield, total alkaloids content in leaf, stem and root and total withanoides content in leaf, stem and root were observed with application of 75% NPK of recommended dose +5 t ha^{-1} vermicompost + PSB and Azotobacter @3 kg ha^{-1} each (Nikhil Malviya *et al*., 2017) [12].

Conclusion

The higher yield obtained in ashwagandha due to integration of inorganic fertilizers, bio fertilizers and organic manures could be due to the higher yield attributing characters like root length and girth, higher dry matter production by higher supply of nutrients, favourable physical and biological environment with increased organic carbon in the soil leading to better root activity and nutrient uptake. As ashwagandha is a root crop, improvement of soil physical environment might be helped in better development of root development.

References

1. Ajay, Ramesh P, Reddy KS, Ramana S, Maji B *et al*. Effect of nitrogen and farm yard manure on physiological parameters in Ashwagandha (*Withania somnifera*) under vertisol soil type. Indian Journal of Plant Physiology. 2005; 10(4):389-393.
2. Dastur JF. Medicinal plants of India and Pakistan. Taraporevala sons and co-operative private Ltd. Treasure house of books, Bombay, 1970, 177-178.
3. Gopal H, Natarajan T, Raja P *et al*. Effect of rhizobacterial inoculation on rhizosphere micro flora of ashwagandha. International Journal of Agricultural Sciences. 2006; 2(2):392-395.
4. Jitendra Patidar, Naruka IS, Shaktawat RPS, Verma KS *et al*. Integrated nutrient management in ashwagandha (*Withania simnifera* (L.) Dunal). Environment and Ecology. 2014; 32(4A):1465-1469.
5. Kaur M, Sharma S, Mishra A *et al*. Influence of phosphate solubilizing pseudomonas and bacillus strains on the growth of ashwagandha (*withania somnifera* L.) Indian Journal of Agriculture Research. 2011; 45(2):128-133.
6. Kaushal Kumar, Sathish Kumar PN, Yadav SK, Uttam, Tripathi AK *et al*. Effect of integrated nutrient management on growth and yield of Ashwagandha (*Withania somnifera* L. Dunal) under water stress condition. Progressive Research. 2013; 8:516-520.
7. Khanna PK, Arun K, Ashok A, Kaul MK *et al*. Effect of biofertilizers on the morphology, root yield and biochemical parameters of *Withania somnifera* (L.) Dunal. Journal of Plant Biology. 2006; 33(1/2):163-167.

8. Kulmi GS and Tiwari PN. Integrated nutrient management in ashwagandha (*Withania somnifera* Dunal). Research on Crops 2006; 7(3):895-899.
9. Maheshwari SK, Sharma RK, Gangrade SK *et al*. Response of ashwagandha (*Withania somnifera*) to organic manures and fertilizers in a shallow black soil under rainfed condition. Indian Journal of Agronomy. 2000; 45(1):214-216.
10. Manna MC, Swarup AM, Wanjari RH, Ravankar HN, Mishra B, Saha MN, Singh YV, Sahi DK, Sarap PA *et al*. Long-term effect of fertilizers and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. Field Crop Research. 2005; 93:264-280.
11. Manohar S, Choudhary MR, Yadav BL, Dadheech S, Singh SP *et al*. Analyzing the efficacy of organic and inorganic sources of nitrogen and phosphorus on growth of ashwagandha (*Withania somnifera* Dunal.). Journal of Horticultural Science. 2012; 7(2):161-165.
12. Nikhil Malviya Naruka IS, Gallani R, Singh OP, Patidar DK *et al*. Effect of integrated nutrient management on growth, yield and quality of Ashwagandha (*Withania somnifera* (L.) Dunal.). Environment and Ecology. 2017; 35(4B):3206-3210.
13. Patil SR, Kattimani KN, Polaiah AC *et al*. Integrated nutrient management in ashwagandha (*Withania somnifera* Dunal.). Plant Archives. 2014; 14(1):373-377.
14. Panchabhai DM, Bachkar BR, Ghawade SM, Wankhade SG *et al*. Effect of nitrogen and phosphorus on growth and seed yield of Ashwagandha. The Orissa Journal of Horticultture. 2005; 33(1):11-15.
15. Panchabhai DM, Bachkar BR, Deokar PL, Wankhade SG *et al*. Effect of nitrogen and phosphorus on root yield and quality of ashwagandha (*Withania somnifera* Dunal.). Advances in Plant Sciences. 2006; 19(1):89-92.
16. Santhi RA, Saranya SA, Appavu KA, Natesan R A, Bhaskaran AB *et al*. Soil test crop response based integrated plant nutrition system for Ashwagandha (*Withania somnifera* L. Dunal) on Inceptisols19th World Congress of Soil Science, Soil Solutions for a Changing World Brisbane, Australia, 2010, 285-288.
17. Shrivastava A, Verma K, Kewat, ML, Nema J *et al*. Effect of integrated nutrient management on quality content of Ashwagandha. Journal of Medicinal and Aromatic Plant Sciences. 2012; 34(½):67-70.
18. Singh M, Naeem M, Khan MN *et al*. Physiomorphological response of *Withania somnifera* as affected by nitrogen fertilization. Advances in Plant Sciences. 2005; 18(2):669-673.
19. Vajantha B, Umadevi M, Patnaik MC, Rajkumar M *et al*. Growth and yield of ashwagandha (*Withania somnifera* L.) as effected by INM and *Panchagavya.* Intl. J Agric. Sci. 2012; 8(1):128-134.
20. Vishal Goel and Duhan BS, Ashwagandha (*Withania somnifera* L. Dunal) crop as affected by the application of farm yard manure (FYM) and inorganic phosphorus in typic Torripsamment of Hisar, African J Biotech. 2014; 13(6):743-748.