ISSN: 0975-833X

Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 09, pp.18967-18972, September, 2021

DOI: https://doi.org/10.24941/ijcr.42227.09.2021

RESEARCH ARTICLE

INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT SYSTEM ON PHENOLOGICAL AND GROWTH ATTRIBUTING CHARACTERS OF ASHWAGANDHA (*WITHANIA SOMNIFERA* L. DUNAL)

Sushmita Chaurasia* and Rashmi Singh

Department of Botany, Govt. P.G. College, Satna 482004 (M.P.), India

ARTICLE INFO

Article History:
Received 29th June, 2021
Received in revised form
14th July, 2021
Accepted 20th August, 2021
Published online 30th September, 2021

Key Words:

Integrated nutrient management system, Phenological characters, Growth attributing characters and Ashwagandha (*Withania somnifera* L.Dunal).

**Corresponding author:*
Sushmita Chaurasia

ABSTRACT

The integrated nutrient management system is important for crop productivity and soil health. Ashwagandha (*Withania somnifera* L. Dunal) 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. A field experiment was conducted during the Kharif season of 2017-18 and 2018-19 near the college of agriculture farm. Tikamgarh, (M.P.) India to study the effect of integrated nutrient management system on phenological and growth attributing characters of Ashwagandha. The twelve treatment combinations of different fertilizers doses, biofertilizers and manures were tested in randomized block design with three replications. Integrated nutrient management system significantly influenced different phenological, growth attributes and physiological parameters of Ashwagandha. The significant maximum values were observed in days to flower initiation (68.5 DAS), plant height (64.74 cm.), several branches per plant (10.69), numbers of leaves per plant (100.40), leaf area per plant (823.81 cm^2) and leaf area index (1.470) with T_{12} treatment (50% NPK/ha+5 tonnes FYM/ha+3kg PSB/ha + 3kg Azotobacter/ha+5kg Zn/ha). While maximum values in days to first fruit maturity (142.5 DAS) and leaf water potential (21.3 -ev bar) were recorded under the T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha). However, the effect on days to germination, days to primary branch, days to secondary branch and days to first fruit initiation was no significant.

Citation: Sushmita Chaurasia and Rashmi Singh. "Clinico- demography Profile and outcome of trauma patients admitted in the emergency department of a tertiary care teaching hospital in Eastern Nepal: A retrospective study*", 2021. International Journal of Current Research, 13, (09), 18967-18972.*

INTRODUCTION

Ashwagandha (*Withania somnifera* L.Dunal.) is an important medicinal plant, of the family solanaceae. It is a perennial branched, evergreen shrub of 30-120 cm height (Fig. 1 A, B). Roots of this plant are mostly used in Ayurvedic and Unani medicines. These are stout, fleshy, cylindrical, but not thicker than 1-2 cm in diameter and are whitish brown. Research has revealed that Ashwagandha possesses anti-inflammatory, anti-tumor, anti-stress, antioxidant, immunomodulatory, hemopoietic and rejuvenating properties, (Mishra *et al.,* 2000 and Khanna *et al*., 2007). Ashwagandha roots are prescribed as medicine for hiccups, several female disorders, bronchitis, dropsy, stomach and lung inflammation, tuberculosis, arthritis and skin diseases. It is also known to improve male potency (Vijayabharati, 2002). It also helps counteract chronic fatigue weakness, dehydration, bone weakness, loose teeth, thirst, impotency, premature aging, emaciation, debility and muscle tension (Singh and Kumar, 1998, Williamson, 2002 and Shrivastava *et al.,* 2018).

Although an important medicinal plant, it is still seen growing on waste and marginal lands, with little or no manures and fertilizers. The use of organic manures and inorganic fertilizers has assumed great importance for sustainable production and for maintaining soil health. These not only supply macro-and micro-nutrients but also improve the physical, chemical and biological health of the soil, leading to good crop production (Bhattacharyya *et al.,* 2005. Yadav and Meena 2009, Hossein and Ghooshchi 2013). The interactive advantage of combining inorganic and organic sources of nutrients generally results in better use of each component (Manna *et al.,* 2005). Hence, the present experiment was designed to optimize the dose of organic manures and fertilizers in the Ashwagandha (*Withania somnifera* L.Dunal) crop.

MATERIALS AND METHODS

Experimental site: A field experiment was conducted during the Kharif season of 2017-18 and 2018-19 near the college of agriculture farm, Tikamgarh, Madhya Pradesh, India (Fig. 2).

a b

Fig. 1 A, B - Ashwagandha (*Withania somnifera* L. Dunal)

Fig. 2. A general view of field experiment

The experimental site lies between the latitude 24^0 26' N to 25^0 40' N and longitude 78^0 26' E to 79^0 28' E at the altitude of 426.7 m above mean sea level. The region received annual rainfall ranging from 800 to 1000 mm and most of which was received from the end of June to the end of September.

Experimental field Soil: Soil analysis revealed that the experimental field soil was clay loam in texture slightly alkaline in reaction having pH 7.4 to 7.6, electrical conductivity 0.33 to 0.37 dS/m at 25^0c and low organic carbon 0.43 to 0.48%. Soil was poor in available nitrogen 189 to 191 kg/ha, phosphorus 17.9 to 18.1 kg/ha, sulphur 15.5 to 16.5 kg/ha, high in available potash 298 to 302 kg/ha, low in DTPA-Fe 6.6 to 6.8 mg/kg, DTPA-Zn 0.37 to 0.41 mg/kg, DTPA-Cu 0.29 – 0.31 mg/kg and DTPA-Mn 2.7 to 3.1 mg/kg.

Sowing of the crop: The seeds of Ashwagandha (JA-20) were sown in each plot at the rate of 10 kg/ ha by hand at depth of 5 cm. in open furrows.

Treatment details: The total experimental area was 46.0 m x 23.0 m and 5.0 m x 4.0 m net plot size. The total twelve integrated nutrient management treatments were applied randomly and replicate thrice in a randomized block design. The details of treatment as mentioned in Table 1.

Table 1. Description of Integrated nutrient management treatments

Treatments	Details of treatment application
T_1	100% NPK recommended dose 50:30:30 kg/ha
T_2	100% NPK/ha+5 kg Zn/ha
T_3	10 tonnes FYM/ha
T_4	10 tonnes FYM/ha + 3 kg PSB/ha
T_5	10 tonnes FYM/ha + 3 kg Azotobacter/ha
T_6	10 tonnes FYM/ha + 3 kg Azotobacter/ha + 3 kg PSB/ha
T_7	10 tonnes FYM/ha + 3 kg Azotobacter/ha + 3 kg PSB/ha + 5 kg Zn/ha
T_8	50% NPK/ha + 5 tonnes FYM/ha
T_9	50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha
T_{10}	50% NPK/ha + 5 tonnes FYM/ha + 3 kg Azotobacter/ha
T_{11}	50% NPK/ha + 5 tonnes FYM/ha + 3 kg Azotobacter/ha + 3 kg PSB/ha
T_{12}	50% NPK / ha + 5 tonnes FYM/ha + 3 kg Azotobacter/ha + 3 kg PSB/ha + 5 kg Zn/ha.

Abbreviation
N = Nitrogen, P= Phosphorus, K = Potassium, Zn = Zinc, FYM = Farm yard manure, PSB = Phosphate, Solubalizing bacteria, kg = Kilogram and ha = Hectare.

Experimental observations: The following observations were recorded for each treatment in all the experimental plots.

Phenological parameters: The various phenological parameters viz, days to germination, days to primary branch, days to secondary branch, days to flower initiation, days to first fruit initiation and days to first fruit maturity were visually observed and recorded in DAS in each treatment.

Growth attributes parameters

Plant height (cm): The plant height at the harvest stage was measured from the ground level to the tip of the plant for five random sample plants from each plot. The average plant height was computed and recorded per plant.

Number of branches per plant: The number of branches at the harvest stage were counted per plant for five random sample plants from each plot. The average numbers of branches per plant were calculated.

Number of leaves per plant: The numbers of leaves at 120 DAS were counted per plant for five random sample plants from each plot. The average numbers of leaves per plant were calculated.

Physiological Parameters

Leaf area (cm^2) per plant: The leaf area per plant at 120 DAS was calculated by multiplying the leaf length x leaf width x K (0.608) x the number of leaves per plant in each plot. Leaf area per plant was determined by using the following formula:

Leaf area = L x W x N x K
Where,
L = Length of a leaf (cm)
W = Width of a leaf (cm)
N = Number of leaves per plant
K = is a constant (0.608)

Leaf area index (LAI): Leaves of five random sample plants in each plot were counted at 120 DAS. LAI was determined by multiplying the products of length and width of the leaf by the constant 0.608. The ratio of leaf area to ground and was taken as leaf area index as suggested by Wastson (1952).

$$LAI = \frac{\text{Leaf area x Number of leaves per plant}}{\text{Ground area}}$$

Leaf water potential (LWP): Leaf water potential at his most succulent stage (*i.e.* at 105 DAS) was determined by the 'Dye method' as per the procedure described by Knipling (1967).

RESULTS AND DISCUSSION

Many studies have been carried out to observe the impact of fertilizers, biofertilizers and manures on the production and quality of several medicinal plants.

This study has mainly focused to determine the effect of twelve treatment combinations of different fertilizers doses, biofertilizers and manures on phonological, growth attributes and physiological parameters of Ashwagandha (*Withania somnifera* L.Dunal).

Table 2. Effect of integrated nutrient management system on phenological parameters of Ashwagandha (Pooled for two years)

Treatment	Days to germination	Days to Primary branch	Days to Secondary branch	Days to flower initiation	Days to first fruit initiation	Days to first fruit maturity
T_1	8.67	46.51	59.31	65.1	86.3	142.5
T_2	8.72	46.61	59.21	65.4	86.7	142.2
T_3	8.56	45.66	58.50	65.8	86.0	141.9
T_4	8.77	45.58	58.82	66.1	87.1	141.6
T_5	7.89	45.52	58.71	66.5	87.4	141.3
T_6	7.95	45.75	58.27	66.8	86.5	141.0
T_7	7.85	45.12	57.75	67.0	86.6	140.8
T_8	8.16	45.44	58.17	67.3	87.1	140.4
T_9	7.99	45.14	58.39	67.6	86.9	140.1
T_{10}	7.84	44.68	57.75	68.0	87.0	139.8
T_{11}	7.76	45.44	57.76	68.3	85.9	139.4
T_{12}	7.89	44.29	57.42	68.5	86.0	138.9
S.Em.±	0.49	0.38	0.45	0.10	0.01	0.11
CD(P=0.05)	NS	NS	NS	0.31	NS	0.33

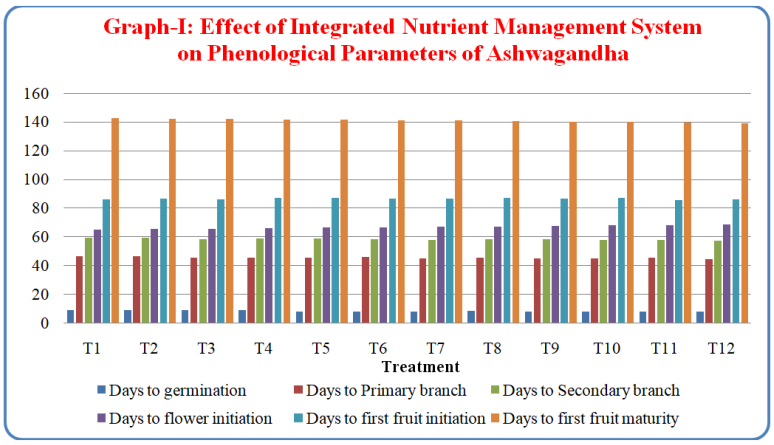


Table 3. Effect of integrated nutrient management system on growth attributes parameters of Ashwagandha (Pooled for two years)

Treatment	Height (cm) per plant at harvest	Number of branches per plant at harvest	Number of leaves per plant at 120 DAS
T_1	46.12	7.61	71.53
T_2	47.36	7.82	73.46
T_3	49.67	8.20	77.03
T_4	51.71	8.54	80.19
T_5	58.05	9.59	90.03
T_6	60.03	9.91	93.10
T_7	56.09	9.26	87.00
T_8	60.37	8.88	83.40
T_9	55.90	9.23	86.70
T_{10}	53.77	9.97	93.63
T_{11}	62.50	10.32	96.93
T_{12}	64.74	10.69	100.40
S.Em.±	0.57	0.09	0.88
CD(P=0.05)	1.69	0.28	2.63

DAS = Days after sowing

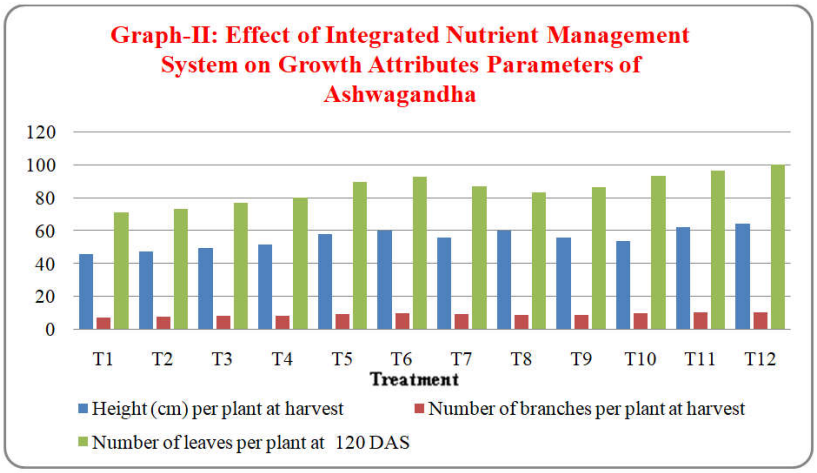
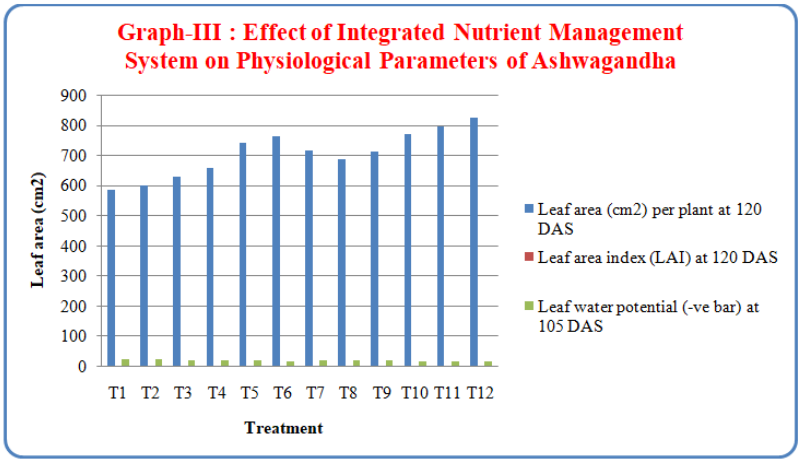


Table 4. Effect of integrated nutrient management system on physiological parameters of Ashwagandha (Pooled for two years)

Treatment	Leaf area (cm^2) per plant at 120 DAS	Leaf area index (LAI) at 120 DAS	Leaf water potential (-ve bar) at 105 DAS
T_1	586.87	0.998	21.3
T_2	602.74	1.009	20.4
T_3	632.02	1.020	19.6
T_4	658.01	1.031	18.9
T_5	738.72	1.086	16.7
T_6	763.89	1.108	16.0
T_7	713.82	1.075	16.6
T_8	684.27	1.042	18.2
T_9	711.36	1.053	17.4
T_{10}	768.27	1.218	15.4
T_{11}	795.36	1.350	14.6
T_{12}	823.81	1.470	13.9
S.Em.±	7.23	0.014	0.22
CD(P=0.05)	21.54	0.043	0.67

DAS = Days after sowing



Effect on Phenological Parameters: The pooled analysis of two years of data given in Table- 2 and Graph-1 indicated that the phenological parameters like days to flower initiation and days to first fruit maturity were significantly influenced by the integrated nutrient management system of Ashwagandha. However, days to germination, days to primary branch, days to secondary branch and days to first fruit initiation were nonsignificant. The maximum delay in flower initiation (68.5 DAS) was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) followed by T_{11} (68.3 DAS) treatment (50% NPK / ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter / ha). The minimum day to taken by crop to initiate flowering (65.1 DAS) was recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha).

The significant minimum day's required to first fruit maturity (138.9 DAS) was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha+3kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) followed by T_{11} (139.4 DAS) treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha) and T_{10} (139.8 DAS) treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg Azotobacter /ha). The maximum day to taken by first fruit maturity (142.5 DAS) was recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha). Delay in days to flower initiation and in days to first fruit maturity may be due to more accumulation of photosynthetic in the plant. Under the optimum condition of moisture and nutrient supply, the photosynthesis would have been translocated from leaves via stem to the sink site resulting in delayed flower initiation and fruit maturity. The results are in very close agreement with the findings of Patidar (2009), Yadav (2010) and Patidar *et al*., (2014).

Effect on growth attributes parameters: The pooled analysis of two years' data indicated that the growth attributes parameters such as plant height per plant, the number of branches per plant and the numbers of leaves per plant of Ashwagandha crop were significantly influenced by different treatments as presented in Table- 3 and Graph-2. Significantly maximum plant height per plant (64.74 cm) was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB / ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) follow by T_{11} (62.50 cm) treatment (50% NPK / ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha). The minimum plant height per plant (46.12 cm) was recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha. This may be due to balanced nutrition on account of the application of FYM, PSB, Azotobacter along with inorganic fertilizers which helped in better cell division, cell expansion and enlargement led to a higher plant height of Ashwagandha. Kurian *et al.,* (2000) and Singh *et al.,* (2004) observed an increase in growth and plant height with the application of fertilizers in different crop plants. Shrivastava *et al.,* (2018) found an increase in plant height of Ashwagandha with the application of FYM, vermicompost and inorganic fertilizers. The results of the present investigation are in confirmation with findings of Patidar *et al.* (2014) in Ashwagandha. Significantly maximum number of branches per plant (10.69) was recorded with T_{12} treatment (50% NPK/ ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) followed by T_{11} (10.32 treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha). The minimum number of branches per plant (7.61) was recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha). The maximum values about the number of branches per plant are the resultant of a better supply of all the major and micronutrients.

Particularly availability of nitrogen in the addition of FYM to the soil in conjunction with chemical fertilizers and biofertilizers increased the availability in absolute amount during the vegetative and reproductive phase. This resulting in more auxin concentration in plant and nitrogen metabolism, increased more number of branches per plant in Ashwagandha crop. Yadav (2010) and Patidar, *et al.* (2014) reported the maximum number of branches per plant of Ashwagandha crop with the application of 50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha. Shrivastava *et al.,* (2018) found the maximum number of branches per plant in Ashwagandha with the application of 100% NPK + 5.0 tonnes/ha FYM + 2.5 tonnes/ha vermicompost + 20 kg $ZnSO_4$.

The maximum number of leaves per plant (100.40) was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) followed by T_{11} (96.93) treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha). The minimum number of leaves per plant (71.53) was recorded with T_1 treatment (100 % NPK recommended dose 50:30:30 kg/ha). The maximum values of the number of leaves per plant indicated the benefits of adding FYM and biofertilizers to the soil in conjunction with inorganic fertilizers which increased the availability of nutrients due to improvement in physical and biological properties of soil, which in turn resulted in the formation of more number of leaves per plant in Ashwagandha crop (Shrivastava *et al.,* 2018). Similar results were reported by Patidar *et al.*, (2014).

Effect on Physiological parameters: The pooled analysis of two years of data given in Table- 4 and Graph-3 showed that the physiological parameters like leaf area per plant, leaf area index (LAI) and leaf water potential (LWP) were also significantly influenced by the integrated nutrient management system of Ashwagandha. T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha was recorded the maximum leaf area per plant (823.81 cm^2). The second best treatment was T_{11} (50 % NPK / ha + 5 tonnes FYM / ha + 3 kg PSB / ha + 3 kg Azotobacter/ha) which recorded 795.36 cm^2 leaf area per plant. The minimum leaf area per plant (586.87cm^2) was recorded with T_1 treatment (100% NPK recommended dose 50: 30: 30 kg/ha).

The maximum leaf area per plant is due to the formation of the maximum number of leaves per plant. Thus, the total photosynthetic surface area was higher in such treatment which resulted in higher leaf area per plant in Ashwagandha. Similar results have also been reported by Patidar (2009), Yadav (2010) and *Patidar et al.,* (2014). Leaf area index (LAI) is used to evaluate many processes such as canopy; photosynthesis and evapotranspiration which play an important role in the transformation of energy and mass between the atmosphere and plant canopy (Weiss *et al.*, 2004). Significantly maximum (1.470) and minimum (0.998) leaf area index of Ashwagandha was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg. PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) and T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha) respectively. The beneficial effect of FYM + biofertilizers + inorganic fertilizers on leaf area index might be due to the synthesis of certain phytohormones and vitamins and more interception of solar radiation and synthesis of more chlorophyll which resulted in a higher leaf area index in Ashwagandha. Similar results have also been reported by Patidar (2009) and Yadav (2010), Patel *et al.,* (2018) and Fazily *et al.,* (2021) reported that the supply of adequate amount nutrients particularly nitrogen at active growth stages of the crop leads to leaf area development and increases leaf area index. Leaf water potential (LWP) indicates the whole plant water status and maintenance of high leaf water potential is found to be associated with dehydration avoidance mechanisms. It is an important physiological factor for the tolerance of water stress in the field. Significantly the lowest leaf water potential (13.9 - ve bar) was recorded with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) followed by T_{11} (14.6 - ve bar) treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha). The highest leaf water potential (21.3 - ve bar) was recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha). It indicates the Ashwagandha crop faced greater stress in T_1 treatment of moisture at the T_{12} treatment perhaps owing to the higher evaporative demand of the crop. Such results corroborate the finding of Ajay *et al.,* (2005).

CONCLUSION

Based on the results of this study, it can be concluded that the integrated nutrient management system significantly influenced different phonological, Growth attributes and physiological parameters of Ashwagandha (*Withania somnifera* L. Dunal). The significant maximum values observed in days to flower initiation, plant height per plant, number of branches per plant, number of leaves per plant, leaf area per plant and leaf area index (LAI) with T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha). While significant maximum values of days to first fruit maturity and leaf water potential (LWP) were recorded with T_1 treatment (100% NPK recommended dose 50:30:30 kg/ha). Results of this investigation indicated that T_{12} treatment (50% NPK/ha + 5 tonnes FYM/ha + 3 kg PSB/ha + 3 kg Azotobacter/ha + 5 kg Zn/ha) was found to be a better-integrated nutrient management system for the cultivation of Ashwagandha (*Withania Somnifera* L. Dunal).

REFERENCES

Ajay, Ramesh P., Reddy, K.S., Ramana, S. and Maji, B. 2005. Effect of nitrogen and farm yard manure on physiological parameters in Ashwagandha (*Withania somnifera*) under vertisol soil type. Indian Journal Plant Physiology 10 (4): 389-393

Bhattacharyya, P., Chakrabarti, K. and Chakrabarti, A. 2005. "Microbial biomass and enzyme activities in submerged rice soil amended with municipal solid waste compost and decomposed cow manure." Chemosphere. 60(3): 310-318.

Fazily, T., Thakral, S.K. and Dhaka, A.K. 2021. Effect of integrated nutrient management on growth, yield attribute and yield of wheat. International Journal of Advances in Agricultural Science and Technology. 8(1): 106-118.

Hossein, S. and Ghooshchi, F. 2013. Response of growth and yield of maize to biofertilizers in organic and conventional cropping systems. The International Journal of Agriculture and Crop Science. 5(7) : 797-801.

Khanna, P.K., Kumar, A., Ahuja, A. and Kaul, M.K. 2006. Biochemical composition of roots of *Withania somnifera*

(L.) Dunal. Asian Journal of Plant Sciences 5 (6): 1061-1063.

Knipling, E.B. 1967. Measurement of leaf water potential by the dye method. Ecology 48:1038-1041.

Kurian, A., Sankar, A., Joseph, L., Keshavachandran, R., Hybe, E.V. and Nair, G.S. 2000. Two decades of research on medicinal plants at College of Horticulture, Kerala Agricultural University, Vellanikkara – An overview. Indian Journal of Arecanut spices and Medicinal Plant. 2(4): 115-139.

Manna, M.C., Swarup, A.M., Wanjari, R.H., Ravankar, H.N., Mishra, B., Saha, M.N., Singh, Y.V., Sahi, D.K. and Sarap, P.A. 2005. 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 Res. 93:264 – 280

Mishra, L.C., Singh, B.B. and Simon Dagenais, B.A. 2000. The scientific basis for the therapeutic use of *Withania Somnifera* (Ashwagandha): A Review Journal of Clinical Therapeutic. 5(4): 334-346.

Patel, G.G., Sadha, A.C., Patel, H.K., Shan, S.N. and Lakum, Y.C. 2018. Effect of organic and inorganic fertilizers in comparison with humic acid on growth and yield of wheat (*Triticum aestivum* L.) International Journal of Agriculture Sciences. 10:6524-6527.

Patidar, Jitendra 2013. Effect of Integrated Nutrient Management for Growth, Productivity and Quality of Ashwagandha (*Withania somnifera* L. Dunal.) M. Sc. (Ag) thesis, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.).

Patidar, Jitendra., Naruka, I.S., Shaktawat, R.P.S. and Varma, K.S. 2014. Integrated nutrient management in Ashwagandha (*Withania somnifera* L.Dunal). Environment and Ecology. 32 (4A) : 1465 – 1469.

Shrivastava, A.K., Upadhyay, V.B., Gautam, D.S., Sarvade, S. and Sahu, R.K. 2018. Effect of integrated nutrient management on growth and productivity of *Withania somnifera* (L.) Dunal in Kymore plateau and Satpura hills of Madhya Pradesh, India. Archives of Agriculture and Environmental Science. 3 (2): 202-208.

Singh, K., Singh, P., Bey, S., Kumar, D. and Patra, D. 2004. Effect of NPK fertilizers on growth, oil yield and quality of french basil (*Ocimum basillicum* L.). Journal of Spike and Agreomatic crops. 13(1): 52-54.

Singh, S. and Kumar, S. (1998). *Withania Somnifera*: The Indian ginseng Ashwagandha. Central Institute of Medicinal and Aromatic Plants, Lucknow, India.

Vijayabharati, J.A.N. 2002. Integrated nutrient management of Ashwagandha for growth, yield and quality. M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Madurai.

Watson, D.J. 1952. The Physiological basis of variation in yield. Advan. Agron, 4:101-145.

Weiss, M., Baret, F., Smith, Gj., Jonckheere, I. and Coppin, P. 2004. Review of methods for in situ leaf area index (LAI) determination. Part II, Estimation of LAI errors and sampling. Agriculture and Forest Meteorology 121: 37-53.

Williamson, E.M. 2002. Major Herbs of Ayurveda: Churchill Livingstone, London, U.K. pp. 322-323.

Yadav, M.S. 2010. Impact of fertilizers and manure on production and quality of Ashwagandha, M.Sc. (Ag.) thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.).

Yadav, R.L. and Meena, M.C. 2009. Available micronutrient status and their relation with soil properties of Degana soil series of Rajasthan. Journal of the Indian Society of Soil Sciences. 57 (1): 90-92

****