Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6[5] April 2017: 01-10

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

REVIEW ARTICLE **OPEN ACCESS**

A Review on Growth, yield and quality attributes of medicinal plant Ashwagandha (*Withania somnifera.* Dunal) under Organic farming and Environmental changes

Meena Kumari *1, Shweta2, Anita Rana2
1* Ph.D. Environmental Science, Department of Environmental Science, College of Forestry
2. Ph.D. Biochemistry, Department of Chemistry and Biochemistry
CSK Himachal Pradesh Agricultural University, Palampur 176062 India
*Corresponding Author: meena.sankhyan@gmail.com

ABSTRACT

Ashwagandha (Withania somnifera. Dunal) 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. Ashwagandha is native to the dry regions of south central Asia, and thrives in a Mediterranean-type climate. It is a stout shrub. Withania somnifera also known as Indian ginseng, Ashwagandha,Winter cherry, Ajagandha, Amukkuram in Malayalam and Samm Al Ferakh. Plant is with erect branching, wild herb. The cultivated plants are morphologically distinct from wild forms. Supplies of roots for medicinal purposes, is being done mostly from cultivated plants. Entire plant is uprooted for collection of roots. It requires dry climate for better growth and root development but winter temperatures are known to improve the root quality. There is a growing concern about adverse effect of use of chemical fertilizers and chemical pesticides.Whereas the organic manures are bulky in nature and supply organic matter in large quantities. Since these manures contain plant nutrients in varying amounts, they have a direct effect on plant growth like any other commercial fertilizer. These manures provide food for soil microorganisms; thus increase the activity of microbes, which in turn helps to convert unavailable plant nutrients into available forms. Organic manures improve the physical properties of soils, which is very beneficial for plants. Looking at the ill effects of such chemicals, it was considered of interest to use organic manures like farmyard manure and vermicompost. These both manures are very beneficial for proper growth and crop production. Vermicompost is a nutrient-rich, natural fertilizer and soil conditioner. It also contains millions of microbes which help break down nutrients already present in the soil into plant-available forms. Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. Various environmental conditions are also seems to be responsible up to much extent to affect growth and development of ashwagandha in different conditions. Hence it is important to study the effect of environmental conditions on ashwagandha. As the quality of root is an important parameter for its marketability, the factors affecting its quality need to be studied and optimized for making ashwagandha cultivation the most remunerative.

Keywords: *Organic farming, Vermicopost, W. somnifera*

Received 01.01.2017 Revised 15.01.2017 Accepted 18.02.2017

INTRODUCTION

Ashwagandha (*Withania somnifera.* Dunal) is an important medicinal plant with a number of valuable medicinal uses. Ashwagandha 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. It is generally distributed in drier parts of India, ascending to 5500 ft. in the Himalayas. Being an important medicinal plant cultivated only in north-western regions of M.P. on about 4000 hectares of land [1].

Ashwagandha (*Withania somnifera.*Dunal) belongs tofamily *Solanaceae*and it attains a height of about 170 cm. The fruits or berries are smooth, spherical, red coloured with 6 mm diameter enclosed in an inflated and membranous calyx. The fruit has small kidney shaped yellow colored seeds [2]. Ashwagandha is native to the dry regions of south central Asia, and thrives in a Mediterranean-type climate. It is a stout shrub. It grows prolifically in India, Nepal, Pakistan, Srilanka and Bangladesh. Organic Ashwagandha is known as *Indian Ginseng*, although the plant has no relationship with actual Ginseng plant native to north eastern Asia. Its use in India's Ayurvedic System of Medicine is as important as is of Ginseng use in Traditional Chinese Medicine System. The species name *somniferous* means *sleep - inducing* in Latin, indicating that it has sedating properties.

Withania somnifera also known as Indian ginseng, Ashwagandha,Winter cherry, Ajagandha, Amukkuram in Malayalam and Samm Al Ferakh. Plant is with erect branching, wild herb. The cultivated plants are morphologically distinct from wild forms. Supplies of roots for medicinal purposes, is being done mostly from cultivated plants. Entire plant is uprooted for collection of roots. This crop is generally taken in late *kharif*season only on conserved soil moisture and can be grown on any type of soils having good drainage with 7.5 to 8.0 pH. It requires dry climate for better growth and root development but winter temperatures are known to improve the root quality [3]. The areas receiving 67-75 cm rainfall are best suited for its cultivation. Ashwagandha root contains 0.4 – 1.2 per cent alkaloids, 40 - 65 per cent starch, 40 - 65 per cent fibers and minor quantity of oil. The important chemical constituents are alkaloids (Withanolides) that are present in roots, leaf and berries [4].Main active constituents are 'somniferum', 'withananine'. Several preparations related to nervous systems contain the drug of this plant. Roots yield important drugs useful in all types of skin lesions, paralytic conditions, ulcers, in reducing pus formation and in rheumatic pain inflammation of joints. *Ashwagandha* in Sanskrit means "horse's smell," probably originating from the odor of its root which resembles that of horse's sweat.

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 like farmyard manure and vermicompost. These both manures are very beneficial for proper growth and crop production. Vermicompost (also called worm compost, vermicast, worm castings, worm humus or worm manure) is the end-product of the breakdown of organic matter by some species of earthworm. Vermicompost is a nutrient-rich, natural fertilizer and soil conditioner. The process of producing vermicompost is called vermicomposting. Vermicompost is richer in many nutrients than compost produced by other composting methods. It also contains millions of microbes which help break down nutrients already present in the soil into plant-available forms [1]. Unlike other compost, worm castings also contain worm mucus which keeps nutrients from washing away with the first watering and holds moisture better than plain soil. Worm compost is usually too rich and gummy for use alone as a seed starter, and is used as a top dressing or mixed with soil in a ratio of one to four. Most fruit and seed pits are reported to germinate in vermicompost easily.Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P_2O_5 and .0.5 per cent K_2O. Organic manures are bulky in nature and supply organic matter in large quantities. Since these manures contain plant nutrients in varying amounts, they have a direct effect on plant growth like any other commercial fertilizer. These manures provide food for soil microorganisms; thus increase the activity of microbes, which in turn helps to convert unavailable plant nutrients into available forms. 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. Various environmental conditions are also seems to be responsible up to much extent to affect growth and development of ashwagandha in mid hill conditions. Hence it is important to study the effect of environmental conditions on ashwagandha. As the quality of root is an important parameter for its marketability, the factors affecting its quality need to be studied and optimized for making ashwagandha cultivation the most remunerative. Hence, it is very important to study the variations in Ashwagandha through organic farming under different environmental conditions in Himachal Pradesh resulting less stress on harvesting from natural habitat (conservation) and enhance the income of the small and marginal farmers of the state.

1.1. History and status of Ashwagandha.
1.2 Effect of organic manures in crop production.
1.3 Growth, development and yield in Ashwagandha
1.4 Effect of environment on crop growth
1.5. Biochemical parameters
1.6. Correlation analysis.

1.1 History and status of Ashwagandha.

Ashwagandha is very important medicinal plant with a number of valuable medicinal uses. Tripathi*et al.* [5] during their study presented a status report on Ashwagandha (*Withania somnifera.*Dunal) which is used in Indian traditional medicine. According to that report, in Ayurveda the roots of Ashwagandha are attributed with properties of health maintenance and restoration. The properties of Ashwagandha roots and restorative properties of ginseng roots are similar due to which Ashwagandha is called as 'Indian Ginseng'. They have also reviewed about the Ayurvedic preparations/formulations made from Ashwagandha, chemical constituents of various plant parts and biochemical activities of various constituents.

The ex-situ conservation of five important medicinal plants i.e. *Aloe barbadensis* (Ghee-kunwar), *Asparagus recemosus*(Satavari), *Costusspeciosus* (Keu), *Rauvolfiaserpentina* (Sarpagandha) and *Withania somnifera* (Ashwagandha) which have already been declared in the category of threatened/rare species in Madhya Pradesh and Uttar Pradesh [6]. A brief description of these plants with medicinal importance, conservation strategies, mode of multiplication etc. in experimental garden of Botanical Survey of India, Allahabad has been provided to encourage their conservation/multiplication.

Ashwagandha (*Withania somnifera*) is a multi-purpose medicinal plant offering solutions for a number of diseases and for restoration of healthy balance of life. Traditional uses and research results on biological activities of Ashwagandha have been reviewed here. Traditionally, Ashwagandha roots are used for nervousness, insomnia, weakness, anaemia, rheumatic pains, general debility and impotence and has abortificient, anodyne, bactericidal, contraceptive, emenagogual, narcotic, sedative, spasmolytic and tonic properties. Research has shown that the roots have anti-inflammatory, antioxidant, anticancer, tranquilizer, immunostimulatory, aphrodisiac, diuretic and adaptogenic uses [7].

The immunomodulatory activity of "ashwagandha churna", a reputed Ayurvedic herbal formulation based on *Withania somnifera*. The experimental paradigms used were cellular (foot pad swelling) immune responses to the antigenic challenge by sheep RBCs (SRBCs) and the neutrophil adhesion test. On oral administration, ashwagandha churna showed a significant increase in neutrophil adhesion and delayed-type hypersensitivity response. It is concluded that ashwagandha churna significantly potentiated the cellular immunity by facilitating the footpad thickness response to SRBCs in sensitized rats [4].

Gupta and Rana[8] presented a review article on Ashwagandha. According to that article *Withania somnifera* is a commonly used herb in Ayurvedic medicine. Although the review articles on this plant are already published, this review article is presented to compile all the updated information on its phytochemical and pharmacological activities, which were performed by widely different methods. Studies indicate ashwagandha possesses antioxidant, anxiolytic, adaptogen, memory enhancing, anti-parkinsonian, antivenom, antiinflammatory and antitumour properties. Various other effects such as immunomodulation, hypolipidaemic, antibacterial, cardiovascular protection, sexual behavior, tolerance and dependence have also been studied. These results are very encouraging and indicate this herb should be studied more extensively to confirm these results and reveal other potential therapeutic effects. Clinical trials using Ashwagandha for a variety of conditions should also be conducted.

A study conducted to create awareness among people on the proper use and collection of medicinal plants containing high levels of heavy metals and their adverse health effects. They stated that amount of heavy metals was determined in the medicinal plant *Withania somniferous* as well as in the soil it was grown in using atomic absorption spectrophotometer. The plant samples were collected from three different locations of NWFP, Pakistan. The plant parts including roots, stem, leaves and fruits were found to have the quantity of heavy metals corresponding to their content in the soil. Results showed that plants grown in contaminated areas have risk of having heavy metal concentrations beyond permissible limits compared to those growing in less contaminated areas [9].

Thangavel*et al*. [10] analyzed the protective effect of *Withania somnifera*, an indigenous medicinal herb used in Ayurvedic traditional systems for more than 3000 years in India, on gentamicin induced nephrotoxicity. The root extract of three different doses of *Withania somnifera* (viz., 250, 500, and 750 mg/kg) was administered orally to rats for 14 days before gentamicin induced nephrotoxicity treatment and thereafter concurrently with gentamicin induced nephrotoxicity (100 mg/kg) for 8 days. Nephrotoxicity was evident in gentamicin induced nephrotoxicity treated rats by significant increase in kidney weight, urea, creatinine, urinary protein, and glucose, and significant reduction in body weights and potassium, which was histopathologically confirmed by tubular necrosis.

1.2 Effect of organic manures in crop production.

i). Effect of FYM on seed yield

As organic manures are bulky in nature and supply organic matter in large quantities. Since these manures contain plant nutrients in varying amounts, they have a direct effect on plant growth like any other commercial fertilizer.Devarajan and Palaniappan[11] observed that the application of FYM @ 10 t ha^{-1} recorded significantly higher the seed yield (1085 kg ha^{-1}) compared to application of NPK @ 20: 80: 40 kg ha^{-1} (943 kg ha^{-1}) in soybean. Jain and Tiwari[12] reported that the application of FYM @ 5 t ha^{-1} + sugar press mud @ 5 t ha^{-1} recorded significantly higher seed yield (1508.67 kg ha^{-1}) and straw yield

(3492.20 kg ha^{-1}) compared to application of FYM @ 4 t ha^{-1} (107.17 ha^{-1}, 2899.30 kg ha^{-1}, respectively) in soybean.

In soybean that the application of enriched FYM recorded significantly higher mean number of pods per plant (164), number of seeds per pod (2.30) with test weight of 8.40 g. The maximum mean soybean seed yield of 2031 kg ha^{-1} was obtained application of enriched FYM, which was 32 per cent higher over control [13].Ashwagandha or Asgandh (*Withania somnifera*) is an important medicinal plant which is attacked by several insect pests, including the spotted leaf beetle Epilachnavigintioctopunctata. The results revealed that farmyard manure (FYM) at 12.5 t/ha + Azophos (2 kg/ha) + neem cake (1000 kg/ha) was very effective in reducing the damage of spotted leaf beetle by 69.79 per cent. The FYM + Azophos + neem cake combination was less preferred for oviposition, which recorded 62.00 ova/plant, coupled with a minimum feeding area of 6.75 cm^2 [14].

ii).Effect of vermicompost on seed yield

Similarly vermicompost is very rich in nutrients which are required plant growth and development. The application of vermicompost @ 5 t ha^{-1} + 50 per cent RDF recorded significantly higher value of growth yield components and yield of sunflower compared to FYM @ 5 t ha^{-1} + RDF [15]. In sorghum combined application of RDF + vermicompost @ 2.5 t ha^{-1} and azospirillum @ 10 kg ha^{-1} resulted in significant increases in yield (5.08 t ha^{-1}) when compared to the application of RDF alone.In case of groundnut maximum pod yield (30.04 q ha^{-1}) was with the application of vermicompost @ 2.50 t ha^{-1} + fly ash @ 30 t ha^{-1} + RDF. Whereas, the lowest pod yield (20.66 q ha^{-1}) was recorded with application of RDF alone [16].Application of vermicompost @ 10 tha^{-1} recorded significantly higher seed yield (2415 kg ha^{-1}), biological yield (9,523 kg ha^{-1}).

The application of vermicompost @ 15 tha^{-1} to soybean recorded significantly higher number of pods per plant (59.00), 100 seedweight (15.80 g), seed yield (1143 kg ha^{-1}), seed protein content (41.80 %) and seed oil content (24.30%) over the application of FYM @ 5 t ha^{-1} + 50 kg N ha^{-1} (29.70, 139, 782 $kgha^{-1}$, 38.70% and 23.00% [17]. Chinnamuthu and Venkatakrishnan[18] reported that the application of vermicompost @ 2 t ha^{-1} recorded significantly higher plant height (147.80 cm) and 100 seed weight (4.14 g) compared to application of FYM @ 5 t ha^{-1} (140.80 cm and 4.06 g, respectively) in sunflower.

1.3 Growth, development and yield in Ashwagandha.

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) and farmyard manure (FYM at 10 t/ha) 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} [19].

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 recorded the highest values for growth, chlorophyll content, nitrate reductase activity, and leaf protein and nitrogen contents [20].Khanna*et al*. [21] conducted a field experiment in Jammu, India, during 2003-04 with 2 biofertilizers (Azotobacterchroococcum and Azospirillumbrasilense) 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, respectively) than *Azotobacter chroococcum* (73.7 and 24.7, 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), poultry manure (PM; 5 t/ha), goat manure (GM; 5 t/ha) or vermicompost (VMC; 5 t/ha), 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), dry root yield (643 kg/ha) and net profit (35 380 rupees/ha) were greatest with VMC. 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) [22].
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 [23]. Panchbhai *et al.* [24]executed a field experiment in Akola, Maharashtra, India during 2000 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; and P at 0, 25, 50 and 75 kg/ha. Maximum root yields were obtained with N at 50 kg/ha (825.6 kg/ha) and P at 25 kg/ha (836.7 kg/ha). The maximum alkaloid content was obtained with N at 50 kg/ha (0.44%) and P at 50 kg/ha (0.42%). More alkaloid content in roots was obtained with the treatment N: P at 50:50 and 50:75 kg/ha than with other treatments.
The previously developed sustainability indices suffer from non-inclusion of effect of amount and distribution of rainfall and were considered as independent of climatic effect. Under dry land farming the effect of rainfall on crops cannot be ignored while screening them for sustainability. In view of this, sustainability index should be made independent of rainfall effect. Hence, a statistical measure of sustainability index, which is a function of estimate of error derived from a regression of yield through rainfall, is used. The sustainability index is a ratio between differences of mean and standard error (detrend for rainfall) to the maximum-recorded yield during the period [25].
The effects of different plant extracts on the growth and yield of black nightshade (*S. nigrum)* were determined in a field experiment conducted in Coimbatore, Tamil Nadu, India during the rabi season of 2002-03. The treatments comprised foliar application of the organic product, Panchagavya (2, 3 and 4%), Mukiamaderas patana leaf extract (1, 2 and 5%), Moringaoleifera leaf extract (1 and 2%), Prosopisjuliflora leaf extract (1, 2 and 3%) and *Withania somnifera* powdered root extract (1, 2 and 3%) 35, 50 and 65 days after sowing of black nightshade [26]. Sang *et al*. [27] performed a number of experiments on aswagandha and their aim of the study was to establish whether the quantity and the quality of light affect growth and development of *Withania somnifera* plantlets. They have studied growth and histo-physiological parameters of *Withania somnifera* plantlets regenerated under various light intensities, or monochromatic light or under a mixture of two colors of light in tissue culture conditions. Plantlets grown under a photon flux density (PFD) of 30 micro mol m^{-2} s^{-1} showed greater growth and development than those raised under other PFDs. Chlorophylls and carotenoids , numbers of stomata, rate of photosynthesis (PN) and transpiration (E), stomatal conductance, and water use efficiency (WUE) increased with increasing the PFD up to 60 micro mol m^{-2} s^{-1}. Light quality also affected plantlets growth and physiology.
Chemical fertilizers also influence the dry root yield and quality of ashwagandha. In Anand, Gujarat, India, to study the influence of MH-30 [maleic hydrazide] and Cycocel [chlormequat] on the growth and dry root yield of aswagandha (*Withania somnifera*). MH-30 (300, 400 and 500 ppm) and Cycocel (100, 150 and 200 ppm) were sprayed thrice at 45-day intervals. The growth attributes, i.e. plant height, root length and root girth, were not significantly influenced by the growth regulate treatments. However, MH-30 (400 ppm) and Cycocel (150 ppm) were found to be effective for increasing the dry root yield and improving the quality of ashwagandha [28].
Mohsina and Datta[29] stated that a broad-leaf plant showing normal cytological behavior and possessing higher yield (root and seed) and yield-related traits was selected from *Withania somnifera* cv. Poshita in kharif 2004 in Nadia, West Bengal, India, and evaluated during 2005-06. The yield and yield-related traits (fresh weight of plant, plant height, root length, root yield, number of primary branches per plant, number of total branches per plant, number of berries per plant, and fresh weight of leaves) increased significantly in the selected plants with respect to the control plants (except for number of primary branches per plant) in 2005-06.

1.4 Effect of environment on crop growth

Environmental factorsalso affects the crop growth and various stages of growth of plants. Hearn [30] studied the effects of environment and genotype on growth and yield of cotton in 3 experiments at Namulonge in 1966. Treatments were sowing date, cv., fertilizer application, plant population and irrigation. BPA 66 sown in June at 4-10 plants/m^2 out yielded other cv., sowing dates and plant densities; 1.25 t compound fertilizer/ha and irrigation increased yields by 15 and 38%, respectively. Soil water deficit (SWD) did not affect growth until a critical value (CD) was reached, which increased from 20 to 50 mm as the crop aged. When CD was reached, the relative water content (RWC) of the plant was 0.94 at dawn and 0.83 at 1400 h.

Jones *et al*. [31] studied the effects of irrigation management strategies on crop yield. The combined model was used to simulate field plot irrigation experiments in Gainesville, Florida. Simulated yields were found to compare favourably with experimental yields. 17 yr of historical weather data were then used to study the effects of various irrigation strategies on expected yield when using a centre pivot irrigation system. Strategy components were allowable soil profile depletion and amount of water per application. Uncertainties or risks, associated with yield for each strategy were expressed as variances of simulated yields resulting from variability in weather.

The impacts of climate change on agricultural crops and livestock. Starting from the basic processes controlling plant growth and development, the possible impacts and interactions of climatic and other biophysical variables in different agro-environments are highlighted. Special attention is given to the problems encountered when scaling up physiological responses at the leaf- and plant level to yield estimates at regional to global levels by using crop simulation models in combination with geo-referenced, agro ecological databases. Some non-linear crop responses to environmental changes and their relations to adaptability and vulnerability of agro ecosystems are discussed [32].

The impact of global warming (change of temperature and rainfall) on crop yield in Saga, Japan [33] was numerically investigated using the SWAP model. It was estimated that the mean temperature in 2100 was higher than 2.15^oC than that in 2003. Since 1967, the mean and standard derivation of rainfall obtained by the probability distribution was nearly 0.76 and 0.43, respectively. The change of soybean yield with increasing mean temperature was simulated by the SWAP model. As a result, the crop yield decreased in the year of high annual average temperature and less annual precipitation and increased in the year of low annual average temperature and much annual precipitation with increasing mean temperature.Kumar and Singh [34] studied thirty triple tests cross families raised in normal and moisture stress environment to detect and measure the interaction between the environments and additive, dominance and epistatic effects of the genes for different plant parts at various growth stages. Leaf showed significant negative association with the stem, root, siliquae and seed. Mishra *et al.* [35]found that stem borer damage had a positive significant correlation with maximum, minimum temperature and a negative correlation with relative humidity. However in the present study a negative correlation was observed with maximum temperature, minimum temperature, rain fall and evaporation.

1.5 Effect of manures and environment on biochemical parameters.

Ocimum sanctum yield of herbage and oil was highest when crop is harvested between the early and late seedlings stages of growth [36] whereas the eugenol content was highest (52.2%) at the late seedling stage. N application increased the growth but did not affect euginol content. Skaltsa*et al*. [37] reported pigennin, luteolin, apigenin 7-0 beta–D- rutinopyranoside, luteolin 7-0 beta glucopyranoside, vincenin-2, vitexin, isovitexin, orientiniso-orienti, chlorogenic acid and caffeic acid isolated from aerial parts of *Ocimum sanctum*.The various organic and chemical fertilizers affect greatly the various biochemical parameters like chlorophyll, total phenols and glucosides. The relevant references pertaining to subject matter of the thesis are presented hereafter. The chlorophyll is thought to increase in the vegetative stages up to a certain period and then starts declining towards maturity, invariably.

In *Trianthemamonogyna* L. the chlorophyll content decline during the later stage of development. The highest amount of total chlorophyll was observed in young maturing leaves. Chlorophyll content decrease drastically during senescence. Marked decrease in Chlorophyll a: b ratio indicated more degradation of Chlorophyll a over Chlorophyll b during senescence [28].Adnyana*et al.* [38] showed five new triterpeneglucosides, quagranosides I-V (1.5), were isolated from a MeOH extract of seeds of *Combretum quadrrangulare*, together with 13 known compounds. Maheshwarappa and Nanjappa (2000) reported that content of chlorophyll a and b was significantly higher in FYM +NPK and NPK alone in arrow root (*Marantaarundinacea* L). Plants treated with FYM + NPK had the highest dry matter at 120 and 240 days after and harvest.Fu *et al*. [39] reported that chlorophyll a and chlorophyll b content was maxim at 15 days after flowering and rapidly decreased after 33 days of flowering in soybean. In sugarcane hybrids, chlorophyll a, b and total contents were maximum at early stage of growth, chlorophyll a/b ratio; however, was maxim at ripening stage. A slight fluctuation in chlorophyll is enough to trigger changes in physiological processes of the plants including photosynthesis [40].

Dioscorea pentaphylla and *Athyrium hohenakerianum* were rich in proteins, carbohydrates and polyphenols. Chlorophyll a and b and total sugar contents were higher in *A. hohenackerianum* than in *D. pentaphylla*[41].Azizi and Omid[42] studied that in St. John's wort 250 kg N treatment increased the number of flowering stems, and hypericin and chlorophyll contents of the herb compared to control. Aroiee and Qmid-Bbaigi[43] reported that increasing the fertilizer rate increased the amount of chlorophylls and N content of leaves in pumpkin compared to the control. The highest rate of chlorophylls and N content of the leaves was obtained when N was applied 300 and 225 kg/ha levels. Compost at different levels significantly increased the vegetative growth characters and yield components in *Sideritis Montana* L. The photosynthetic pigments (Chlorophyll a, b and total carotenoids) and carbohydrate content as well as oil percentage and yield per plant were greatly affected by compost fertilization and reached the, maximum values with its highest level(16.5 t/ha).

New phenyl ethanoid glycoside, persicoside and three known phenyl ethanoids glycosides, acetosides, iso-acteoside and lavandulifolioside, were isolated from aerial parts of *Veronica persica*[44]. The highest yields were obtained in stinging nettle (*Urticadioica* L) with 60 t cattle manure and 150-200 kg N/ha. The highest chlorophyll content were obtained with cattle manure at 60 t/ha and 200kg N/ha. The Mg content was also enhanced with cattle manure and N fertilizers [45].

In chilli, the chlorophyll content was higher in vermicompost + neem cake treatment on 30 days after sowing. On 60 days of sowing, higher chlorophyll b and total chlorophyll contents were observed in treatment containing vermicompost alone. On 90 days after sowing, Chlorophyll a and total chlorophyll content was higher in vermicompost alone, and Chlorophyll b in the vermicompost + FYM treatment [46].Singh and Naeem[47] conducted a study to determine the effect of phosphorus (0, 20, 40 and 60 kg/ha) on the growth and carotinoid and chlorophyll contents of *Withania somnifera.* 60Pkg/ha gave the highest fresh weight per plant, dry weight per plant, number of leaves per plant, dry leaf weight per plant, leaf area, carotenoids, chlorophyll a, chlorophyll b and total chlorophyll. All N treatments were effective in enhancing all physio-morphological parameters in comparison with the control in *Withania somnifera*. N at 90 kg/ha recorded the highest values for growth, chlorophyll content, nitrate reductase activity and leaf protein and nitrogen contents by Singh *et al.*[48].

Shivputra*et al*. [49]revealed that the increased chlorophyll accumulation was observed in VAM- treated plants of Papaya. There was increase in the NPK and Chlorophyll content in vermicompost applied plants. The efficacy of VAM plants increased with application of vermicompost, wherein both the VAM species registered significantly higher values of NPK and chlorophyll. While in an experiment in Madhya Pradesh, India to study the effect of farmyard manure (FYM at 10 t/ha) 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 [19].Ajay *et al*. [19] reported that total phenols and ortho-dihydric phenol content decreased with application of nitrogen in pre flowering stage in *Withania somnifera* but increased with application of nitrogen at post flowering stage. Root yield was maximum at 20 kg N/ha. Rao and Rajasekhara[50] found the organically manured treatments like FYM, neem cake, vermicompost recovered lowest pest population compared to straight fertilized treatments. The groundnut plants that received organic manures recorded low nitrogen, higher levels of tannins and phenols.

The soluble protein, total amino acid, reducing sugar, non-reducing sugar and starch contents of the fresh roots and the crude fiber content of the dry roots of *Withania somniferous* accessions AGB-002, AGB-009, AGB-015, AGB-025 and AGB-030 of *Withania somnifera*, during the young and mature stages of the crop. All the accessions followed a uniform pattern of maximum biochemical constituent accumulation during maturity. The accession AGB-002 was more efficient in the accumulation and synthesis of biochemical constituents during the 2 stages of root growth [7].Prakash*et al.*[51] stated that Phenols, a major group of antioxidant phytochemicals, have profound importance due to their biological and free radical scavenging activities. To identify their potential sources, extracts of some plants were studied for their total phenolic content (TPC), antioxidant (AOA) and free radical scavenging activities (FRSA) by different methods at multiple concentrations followed by specific phenolic composition.

2.9. Correlation analysis

Among the different crop plants, there are correlations among different yield components. In crop plants the correlation may be positive, negative and both positive and negative.Using hand held portable chlorophyll meter (SPAD-502) Ma *et al.*[52] found that the relationship between photosynthesis and leaf area and specific leaf weight were non-significant or were inconsistent across growth stages. The results suggested that chlorophyll readings are quick, reliable and repeatable indicators of leaf photosynthetic rate that can be used for screening soybean genotypes.In maize cultivar Yidan 13 and Luyun 10 grain yield was positively correlated with both dry matter accumulation during grain filling (source) and total kernel number (sink) [53]. Grain yield showed significantly negative correlation with days to first flowering, pod initiation and maturity in black bean [54]. In fenugreek, days to flowering showed negative significant as well as negative direct effect on seed yield.

Ahmad *et al.*[55] reported a negative correlation between shoot dry weight and root: shoot ratio in P-stressed plants suggested that increase in root dry weight production was at the cost of shoot dry weight in cotton. Statistically, significant positive correlation were observed between shoot dry weight and some other traits such as root dry weight, leaf area per plant, P-uptake, P-utilization efficiency, at both phenotypic and genotypic levels. Grain yield in *Vigna mungo* had negative correlation with days to flowering, days to maturity, plant height and number of branches per plant.

Grain yield in mung bean showed positive correlation with pod length, pod per plant, 100-seed weight and harvested index and negative correlation with days to maturity [56]. Kusutani and Gotoh[57] reported in cocksfoot cv. Kitamidori that the correlation between dry matter yield and leaf area decreased with increasing growth.In sesame, the correlation studies revealed that seed yield was positively and significantly correlated with plant height, number of leaves, number of branches per plant, number of seed per capsule, total dry matter produced at stage of 75 DAS and at maturity (Singh *et al.* 2000). Similarly in bambara groundnut seed yield was positively correlated with days from sowing to germination, days to maturity, number per pod and 1000-seed weight [58].

Zhang *et al*. [59] recorded that increasing nitrogen fertilizer application rates up to 0.15 g/liter increased growth and other physiological parameters. The net photosynthetic rate of *Glycyrrhizauralensis* showed a significant positive relation with biomass and yield. The nitrogen, phosphorus and potassium content of *G. uralensis*leaves showed linear relation with height, root diameter, single plant weight and yield. Kumar *et al*. [60] reported in millet that the positive association of harvest index with grain yield is indicative of the translocation of photosynthates from source to sink.

REFERENCES

1. Kumari,M. and Upadhyay, R.G. [2012]. Effect of Spacing, Organic Manures and Time of Transplanting on Growth and Yield of Ashwagandha (*Withania somnifera* Dunal) under Mid Hill Zone of Himachal Pradesh. Environment & Ecology, 30 (4): 1272-1275.
2. Nigam, K.B. and Kandalkar, V.S. [1995]. Ashwagandha.Advances in Horticulture,11(3): 335-344.
3. Kahar, L.S.,Tomar S.S., Pathan, M.A. and Nigam, K.B. [1991]. Effect of sowing dates and variety on root yield of Aswagandha.Indian Journal of Agricultural Sciences,16(7): 495-97.
4. Gupta, M.S., Shivaprasad, H.N., Kharya, M.D. and Rana, A.C. [2006]. Immunomodulatoryactivity of the Ayurvedic formulation "Ashwagandha churna". Pharmaceutical Biology, 44(4): 263-265.
5. Tripathi, A.K., Shukla, Y.N. and Kumar, S. [1996]. Ashwagandha (*Withania somnifera*. Dunal (Solanaceae)):a status report. Journal of Medicinal and Aromatic Plant Sciences,18(2):145-152.
6. Dixit, R.D., Kumar, R., Vaish, U.S. and Rawat, V.K. [2005]. Conservation of medicinal plants in the experimental garden of botanical survey of India, Central Circle, Allahabad. Journal of Economic and Taxonomic Botany, 29(4): 831-833.
7. 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.
8. Gupta,G.l. and Rana, A.C. [2007]. *Withania somnifera* (ashwagandha): a review. Pharmacognosy Reviews, 1(1): 129-136.
9. Khan, M.A., Ijaz-Ahmad andInayat-ur-Rahman. [2007]. Effect of environmental pollution on heavy metals content of *Withania somnifera*.Journal of the Chinese Chemical Society, 54(2): 339-343.
10. Thangavel, J. and Perumal, S. [2010]. Protective Effect of *Withania Somnifera* root powder on lipid peroxidation and antioxidant status in gentamicin induced nephrotoxic rats. Journal of Basic and Clinical Physiology and Pharmacology, 21(1): 61-65.
11. Devarajan, R. and Palaniappan, S.P. [1995]. Zinc and molybdenum on yield and nutrition of soybean.Madras Agricultral Journal,82(2): 188-189.
12. Jain, R.C., Tiwari, R.J. and Singh, K. [1995]. Effect of farm yard manure and sugars press mud on productivity and quality of soybean.*Crop Research*,9(2):229-232.
13. Kathireshan, G., Manickam, G. and Gnanmurthy, P. [1999]. Effect of enriched farm yard manure and time of gypsum application on growth and yield of soybean (*Glycinemax*).*Journal of Oilseed Research,*16(2): 348-349.
14. Ravikumar, A., Rajendran, R., Chinniah, C., Irulandi, S. and Pandi, R. [2008]. Induction of resistance through organic amendments for the management of spotted leaf beetle, Epilachnavigintioctopunctata Fab. on Ashwagandha. Journal of Biopesticides, 1(1): 23-27.
15. Kale, R.D., Bano, K., Sreenivasa, M.M. and Bhagyaraj, D.J. [1987]. Influence of worm cast (Vec, comp. E. UAS, 93) on the growth and mycorrhizal colonization of two ornamental plants. South Indian Horticulture,35(2):433-437.
16. Basavanagowda, P.S. [1998]. Studies in integrated nutrient management in summer groundnut (*Arachishyphogea*L.). *M.Sc. (Agri.) Thesis*. University Agriculture Sciences, Dharwad 8(7): 320-338.
17. Aruna, and Narsareddy, S. [1999]. Response of soybean (*Glycine max*) conjuctive use of organic and inorganic sources of nitrogen.Indian Journal Agricultural Science,69(5): 382-383.
18. Chinnamuthu, C.R. and Venkatakrishnan. [2001]. Effect of integrating inorganic fertilizer with vermicompost and vascular arbuscularmycorrhizae (UAM) on the productivity of sunflower.Madras Agricultural Journal,88:(7-9): 424-427.
19. 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 of Plant Physiology, 10(4): 389-393.

20. Singh M., Naeem, M. and Khan, M.N. [2005]. Physiomorphological response of *Withania somnifera* as affected by nitrogen fertilization.Advances in Plant Sciences, 18(2): 669-673.
21. Khanna, P.K., Arun, K., Ashok, A. and Kaul, M.K. [2006]. Effect of biofertilizers on the morphology, root yield and biochemical parameters of *Withania somnifera* (L.)Dunal.Journal of Plant Biology, 33(1/2): 163-167.
22. Kulmi, G.S. and Tiwari, P.N. [2006]. Integrated nutrient management in ashgandh (*Withania somnifera* Dunal).Research on Crops, 7(3): 895-899.
23. Gopal, H., Natarajan, T. and Raja, P. [2006]. Effect of rhizobacterial inoculation on rhizospheremicroflora of ashwaganadha.International Journal of Agricultural Sciences, 2(2): 392-395.
24. Panchbhai, D.M., Bachkar, B.R., Deokar, P.L. and Wankhade, S.G. [2006]. Effect on nitrogen and phosphorus on root yield and quality of ashwagandha (*Withania somnifera* Dunal.).Advances in Plant Sciences, 19(1): 89-92.
25. Sharma, R.A., Sharma, S.K. and Thakur, H.S. [2006]. Sustainability of improved management practices of dryland agriculture in Western Madhya Pradesh. Indian Journal of Dryland Agricultural Research and Development, 21(2): 157-162.
26. Sritharan, N. and Manian, K. [2006]. Physiological and biochemical basis of yield improvement in black nightshade (*Solanumnigrum* L.) through bioregulators.Journal of Plant Biology, 33(3): 185-192.
27. Sang, Lee Ho., Tewari, R.K., Hahn,EunJoo. and Paek,KeeYoeup. [2007]. Photon flux density and light quality induce changes in growth, stomatal development, photosynthesis and transpiration of *Withania somnifera* (L.) Dunal Plantlets.Plant Cell, Tissue and Organ Culture, 90(2): 141-151.
28. Upadhey, A.B. and Karadge, B.A. [1991]. Photosynthesis in *Trianthemamonogyna* L. during leaf development.Indian Journal of Plant Physiology, 34(2): 178-185.
29. Mohsina, I. and Datta, A.K. [2007]. High yielding morphological variation in *Withania somnifera* (L.)Dunal.Plant Archives, 7(2): 553-554.
30. Hearn, A.B. [1972]. The growth and performance of rain-grown cotton in a tropical upland environment. 1. Yields, water relations and crop growth. Journal of Agricultural Science, 79(1): 121-135.
31. Jones, J.W., Hammond, L.C., Boggess, W.G., Swaney, D.P. [1981]. Soybean irrigation strategies under weather uncertainties. Agronomy abstracts 73rd annual meeting, American Society of Agronomy, 214.
32. Rotter, R., Geijn, S.C. and Van, De. [1999]. Climate change effects on plant growth, crop yield and livestock.Climatic Change, 43(4): 651-681.
33. Koriyama, M., Tanaka, A. and Yano, T. [2003]. Impact evaluation of temperature and rainfall change on crop yield with the SWAP model (the impact of global warming on crop production). Bulletin of the Faculty of Agriculture, Saga, University 1(88): 79-86.
34. Kumar, S. and Singh, D. [2003]. Gene effects and genotypes x environment interaction at various growth stages of different biomass characters in Indian mustard.*National* Journal of Plant Improvement, 5(2): 112-115.
35. Mishra, A.K., Singh, S.P.N. and Parwez, A. [2005]. Incidence of yellow stem borer, *Scirpophagaincertulas*(Wlk.) in different cultivars of boro rice (*Oryzasativa*L.). Annals of Agriculture Research,19(1): 89-94.
36. Pareek, S.K., Maheshwari, M.L. and Gupta, R. [1980]. Domestication studies on *Ocimum sanctum* for high oil and eugenol content. Indian Perfumar, 24(2):93-100.
37. Skaltsa, H., Tzakou, O. and Singh, M. [1999]. Polyphenols of *Ocimum sanctum* from Suriname.Pharmaceutical Biology,37(1): 92-94.
38. Adnyana, I.K., Tezuka, Y., Banskota, A.H., Xiong, Q.B., Dim-Qui-Tran and Kadota, S. [2000]. Quadranosides I-V, new *triterpeneglucosides from the seeds of Combretumquadragulare. Journal of Natural Products, 63*(4):496-500.
39. Fu, J., Huang, B. and Zang, G. [2000]. Physiological and biochemical changes during seed filling in relation to leaf senescence in soybean.BiolgiaPlantarum, 43(4):545-548.
40. Kapur, P. [1999]. Chloropnyll as an indicator of light intensity in *Andrographispaniculata*.Indian Journal of Plant Physiology, 4(2):15-19.
41. Vaidya, R.R. and Dhumal, K.N. [2001]. Studies on nutritive values in some vegitables used by tribals of Mahabaleshwer.Journal of Medicinal and Aromatic Plant Sciences, 22/23 (4A/1A):312-313.
42. Azizi, M. and Omid-Beigi, R. [2001]. Effect of different levels of nitrogen and phosphorus fertilizer on growth, yield and hypericin content of St. John's wort. *Iranian Journal of Agricultural Sciences, 32(4): 720-725.*
43. Aroiee, H. and Omidbaigi, R. [2004]. Effects of nitrogen fertilizer on productivity of medicinal pumpkin.Acta-Horticulturae, 7(629): 415-419.
44. Harput, U.S., Saragoclu, I., Inoue, M. and Ogihara, Y. [2002]. Phenylethanoid and iridoid glycosides from *Veronica persica*.Chemical and Pharmaceutical Bulletin, 50(6):869-871.
45. Biesiada, A. [2003]. Effect of manures and nitrogen fertilization on yield and chemical composition of stinging nettle (*Urticadioica* L.).Folia Horticulturae, 15(1): 131-139.
46. Yadav, R.H. and Vijaykumari, B. [2004]. Impact of vermicompost on biochemical characters of chilli (*Capsicum annum*).Journal of Ecotoxicology and Envieronmental Monitoring, 14(1): 51-56.
47. Singh, M. and Naeem, M. [2004]. Effect of phosphorus application on the ashwagandha (*Withania somnifera*).Bionotes, 6(4): 103.
48. Singh, M., Naeen, M. and Khan, M.N. [2005]. Physiological responces of *Withania somnifera* as affected by nitrogen fertilization.Indian Journal of Plant Physiology, 13(6):47-53.
49. Shivputra, S.S., Patil, C.P., Swamy, G.S.K. and Patil, B.P. [2004]. Cumulative effect of VAM fungi and vermicompost on nitrogen, phosphorus, potassium and chlorophyll content of papaya leaf.Mycorrhiza News,16(2): 15-16.
50. Rao, K. and Rajasekhara. [1997]. Induced host plant resistance in the management of sucking insect pests of groundnut. Annals of Plant Protection Sciences, 10(1): 45-50.

51. Prakash, D., Samiksha, S.,Upadhyay, G. and Singh, B.N. [2007]. Total phenol, antioxidant and free radical scavenging activities of some medicinal plants. International Journal of Food Sciences and Nutrition, 58(1): 18-28.
52. Ma, B.L., Morrison, H. and Veldeng, H.D. [1995]. Leaf greenness and photosynthatic rates in soybean.Crop Science, 35(5):1411-1414.
53. Lu, W.P., Chen, G.P., Guo, J.R., Wang, Z.X. and Rao, C.F. [1997]. Study on source and sink in relation to grain yield underdifferent ecological areas in maize. ActaAgronomicasinica, 23(6):727-733.
54. Hatam, M. and Khan, A. [2001]. Correlation between grain yield and agronomics parameters in black bean.Sarhad Journal of Agriculture, 17(3):317-320.
55. Ahmad, Z., Gill, M.A., Shah, A.M., Mahmood, T., Rahman, H.U. and Yaseen, M. [1998]. Differential growth behaviour of cotton varieties at adequate and deficient levels of nitrogen and phosphorus.Pakistan Journal of Biological Sciences, 1(4):342-345.
56. Amanullah and Hatam, M. [2000]. Correlation between grain yield and agronomics parameters in Mungbean (*Vigna radiata (L)*Wilczek.Pakistan Journal of Biological Sciences, 3(8):1242-1244.
57. Kusutani, A. and Gatoh, K. [1979]. Studies on productives of cooksfoot.3.Dry matter production of clonal lines.Journal of Japanese Society of Grassland Sciences, 25(1):1-6.
58. Karikari, S.K. [1972]. Correlation studies between yield and some agronomic characters in bambara groundnut(*Voandzeia subterranean*Thouars).Ghana Journal of Agricultral Science, 5(1):79-83.
59. Zhang, Y.W., Ji Young, and Wang WenQuan. [2005]. Nitrogen nutrition in *Glycyrrhizauralenss* Fisch.Journal of Beijing Forestry University, 27(3):57-60.
60. Kumar, P., Jyothi, L.N., Dube, S.D. and Mani, V.P. [2000]. Genotypic differences in photosynthesis and its associated parameters in relation to yield among farm yard millet (*Echinocholafrumentacea)* genotype under rainfed conditions in hills. Indian Journal of Plant Physiology, 3(3): 229-230.

CITATION OF THIS ARTICLE

Meena Kumari, Shweta, Anita Rana. A Review on Growth, yield and quality attributes of medicinal plant Ashwagandha (*Withania somnifera.* Dunal) under Organic farming and Environmental changes. Bull. Env. Pharmacol. Life Sci., Vol 6[5] April 2017: 01-10