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RD Deotale
Professor, Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

GA Padghan
Ex- M. Sc. Student, Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

SR Kamdi
Assistant Professor, Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

Shanti R Patil
Assistant Professor, Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

Vandana S Madke
Professor (CAS), Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

Correspondence
RD Deotale
Professor, Agricultural Botany Section, College of Agriculture, Nagpur (M. S.), India

Effect of foliar application of humic acid through vermicompost wash and naa on chemical and biochemical parameters and yield of pigeonpea

RD Deotale, GA Padghan, SR Kamdi, Shanti R Patil and Vandana S Madke

Abstract
An experiment was conducted during 2016-17, to study the effects of foliar application of humic acid through vermicompost wash and NAA on chemical and biochemical parameters and yield of pigeonpea cv. PKV- Tara. The experiment was laid down in randomised block design with twelve treatments and three replications at farm of Botany Section, College of Agriculture, Nagpur. The different treatments tested were 25 and 50 ppm NAA and 300, 400 and 500 ppm humic acid (HA) through vermicompost wash (VCW) alone or in combination. One control (Water spray) treatment was also taken. Foliar application 50 ppm NAA + 400 ppm HA through VCW significantly enhanced chemical and biochemical parameters *viz*., nitrogen, phosphorus, potassium and chlorophyll content in leaves, number of pods plant^{-1}, number of seed pods^{-1}, test weight, and protein content in seeds. Seed yield plant $^{-1}$ was also significantly enhanced by same treatment when compared with control and rest of the treatments under study. Considering the treatments under study two foliar sprays of 50 ppm NAA + 400 ppm HA through VCW at 45 and 65 DAS was found to be most effective treatment in improving chemical and biochemical parameters and yield of pigeonpea cv. PKV- Tara

Keywords: Pigeonpea, vermicompost wash, NAA, chemical and biochemical parameters and yield)

Introduction
Food legumes are of prime importance in human diet and animal feed contributing the major source of vegetable protein. They are an economic source of not only protein but of carbohydrate, minerals and B-complex vitamins particularly in vegetarian diet (Salunkhe *et al.*, 1985) [25]. On an average, pulses contain 20-25 per cent of protein in their dry seeds, which is almost 2.5-3.0 times the value normally found in cereals. Thus, the food legumes ensure nutritional security to the poor masses of the country (Chaturvedi and Ali, 2002) [5]. It is a natural mini-nitrogen manufacturing factory in the field and the farmers by growing these crops can play a vital role in increasing indigenous nitrogen production. Legumes are considered as the most important source of food after cereals in the world, as they are main sources of protein and energy for humans (Salih, 2013) [24]. Legumes have certain phytochemicals like polyphenols, flavonoids and phytosterols that possess health benefits (Sreerama *et al.*, 2010) [32]. Pigeonpea seed is composed of cotyledons (85%), embryo (1%), and seed coat (14%) (Faris and Singh, 1990) [8]. Pigeonpea contains 19-23% proteins, 1-2 % fat, 45-55% carbohydrates, 1-5% fibers, 3-5% soluble sugars and energy 16-18% (Lawn and Troedson, 1990) [14]. Humic acid when externally supplied was observed to increase crop growth and ultimately the yield. It includes the nutritional status of soil and plant system. The high cation exchange capacity of humic acid prevents nutrients from leaching. It absorbs the nutrients from chemical fertilizers and these exchanged nutrients are slowly released to the plant. Humic acid proved many binding sights for nutrients such as calcium, iron, potassium and phosphorus. These nutrients are stored in humic acid molecule in a form of readily available to plant and are released when the plants required them. Humic acid increases the absorbance and translocation of nutrients in plants and ultimately influences yield. Humic acid supplies polyphenols that catalyze plant respiration and increases plant growth.

Vermicompost wash is useful as foliar spray. It is transparent pale yellow bio fertilizer. It is a mixture of excretory products and mucous secretion of earthworm (*Lampito mautrii* and *Eisenia foetida*) and organic micronutrients of soil, which may be promoted as "potent fertilizer" for better yield and growth (Shweta *et al.*, 2005) [29].

Vermicompost wash is having approximately 1300 ppm humic acid, 116 ppm dissolve oxygen, 50 ppm inorganic phosphate, 168 ppm potassium and 121 ppm sodium (Haripriya and Poonkodi, 2005) [10]. The economic and social potential of livestock in organic agriculture has long been known. In many countries, now a day the major components of organic agriculture are the use of livestock stock such as vermicompost in crop production. NAA (Naphthalene Acetic Acid) is the synthetic auxin with the identical properties to that naturally occurring auxin. It prevents formation of abscission layer and thereby flower drop. It was observed that the growth regulators are involved in the direct transport of assimilates from source to sink (Sharma *et al.*, 1989) [28]. NAA is synthetic auxin with identical properties to that of naturally occurring auxin i.e; IAA in plant. Auxin in low concentration promotes cell elongation i.e; growth, but in higher concentration it inhibits the growth. Application of growth promoting hormones is a recent technique in this direction. Plant hormones in a broad sense are organic compounds which play an important role in plant growth development and yield of crops to prevent the fruit and flower drop for a longer period.

Material and Methods

The field experiment on "Effect of foliar application of humic acid through vermicompost wash and NAA on chemical and biochemical parameters and yield of pigeonpea" was carried out during at farm of section of Agricultural Botany, College of Agriculture, Nagpur during *kharif* 2016-17. Plot size of individual treatment was gross 4.20 m x 4.40 m and net 3.00 m x 4.00 m. Seeds were sown at the rate of 20 to 22 kg ha^{-1} by dibbling method at a spacing of 60 cm x 20 cm on 1st July 2016. Treatments comprised of T1 (control), T2 (300 ppm HA), T_3 (400 ppm HA), T_4 (500 ppm HA) T_5 (25 ppm NAA) T_6 (50 ppm NAA) T_7 (300 ppm HA + 25 ppm NAA) T_8 (400 ppm HA + 25 ppm NAA) T_9 (500 ppm HA + 25 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA). Foliar application of these treatments was given at two stages i. e. 45 and 65 DAS on pigeanpea.

The chemical and biochemical parameters viz., leaf chlorophyll, nitrogen, phosphorus, potassium and seed protein content were estimated and recorded. Total chlorophyll content of oven dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982) [4]. Nitrogen content in leaves was determined by micro Kjeldahl's method as given by Somichi *et al*. (1972) [31]. Phosphorus content in leaves was determined by vanadomolybdate yellow colour method given by Jackson (1967) [11]. Potassium content in leaves was determined by flame photometer by di-acid extract method given by Jackson (1967) [11]. Nitrogen content in seed was determined by microkjeldhal's method (Somichi *et al*., 1972) [31] and same was converted in to crude protein b multiplying 'N' percentage with factor 6.25. Seed yield $plant^{-1}$ and $plot^{-1}$ were also recorded in gram (g) and kilogram (kg) respectively. The data were analysised as per the method suggested by Panse and Sukhatme (1954) [21].

Results and Discussion

Chemical and biochemical parameters

Leaf chlorophyll

At 45 DAS data regarding chlorophyll content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (45 and 65 DAS). Significantly highest chlorophyll was found in combination treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA) in a descending manner when compared with control and rest of the treatments. At 85 DAS significantly maximum leaf chlorophyll was noticed in combination treatments of T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm HA), T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments. Similarly treatments T_9 (500 ppm HA + 25 ppm NAA), T_6 (50 ppm NAA) and T_5 (25 ppm NAA) also increased leaf chlorophyll significantly when compared with control and rest of the treatments. At 105 DAS significantly highest chlorophyll was found in combination treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and treatment T_8 (400 ppm HA + 25 ppmn NAA). Treatment T_7 (300 ppm HA + 25 ppm NAA) also shown significant effect over the control.

It is observed from the data that chlorophyll content in leaves was maximum at 65-85 DAS but thereafter, gradual decrease in chlorophyll content was noticed at 105 DAS. Nitrogen is a constituent element in chlorophyll which rapidly increases at vegetative stage, as the nitrogen reserves are in ample quantity at this stage. However, rate of nitrogen mobilization is more to the reproductive part than the rate of nitrogen uptake. Hence, increase in chlorophyll content during 65-85 DAS might be due to increased uptake of N, P, K and other nutrients in early stage of plant growth.

Ameri and Tehranifar (2012) [2] worked on *Fragaria ananassa* var. Camarosa to study the effect of humic acid fertilizer on its nutrient uptake (N, P and K) and physiological characteristics. Treatments included different concentrations of humic acid (0, 10, 20, 30 and 40 ppm) with two methods of application (fertigation and spray). In spray method10 and 20 ppm concentrations of humic acid showed highest amount of chlorophyll. Arsode (2013) [1] carried a field experiment on mustard to test the effect of foliar application of humic acid through cowdung wash and NAA and exhibited that 50 ppm NAA + 300 ppm HA through cowdung wash significantly increased leaf chlorophyll content in mustard.

Leaf nitrogen content

It is observed from data that there was significant variation in leaf N content due to foliar sprays of HA and NAA at various concentrations at 65, 85 and 105 DAS.

At 45 DAS data regarding N content was non-significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (45 and 65 DAS). Significant variation was observed at 65, 85 and 105 DAS. At 65 DAS, treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 pm NAA) gave significantly maximum N content. Treatments T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) also exhibited significantly more leaf N as compared to control. At 85 DAS, significantly highest N content was recorded in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Whereas treatments T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) also showed significantly moderate nitrogen content. Nitrogen content at 105 DAS was significantly enhanced by treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by the treatments T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA) when compared with rest of treatments and control in enhancing N content. Treatments T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also shown significant performance over the control.

The inferences drawn from data that leaf N content was gradually decreased from 65-85 and 85-105 DAS. The decrease in N content might be due to fact that younger leaves and developing organs, such as grains act as strong sink demand and may draw heavily N from leaves (Gardner *et al*., 1988) [9]. The above findings are consonance with the findings of Poonkodi (2003) [22]. He stated that decrease in N content in leaves might be due to translocation and utilization of nutrients for flower and pod formation in black gram. At the vegetative period, physiological and metabolic activities are at higher rate and this might be the reason for increase in uptake of nitrogen content from soil at early stage of crop growth. Similarly HA enhance cell permeability, which in turn made more rapid entry of minerals into root cells and so resulted in higher uptake of plant nutrients. This effect was associated with the function of hydroxyls and carboxyls in these compounds. The principal physiological function of HA may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients (Chen *et al.* 2004) [7]. These might be the reasons for increase in leaf N content in the present investigation. Kapase *et al*. (2014) [12] carried out the field experiment to study the effect of humic acid through vermicompost wash and NAA and observed that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced leaf N content in chickpea. Mosa *et al.* (2015) [16] examined ten treatments i.e. control, sprayed with water, K at 2% as potassium sulphate, Ca at 0.2% as calcium chloride, B at 0.2% as boric acid, H.A. at 5% as humic acid, potassium sulphate + humic acid, calcium chloride + humic acid, boric acid + humic acid, potassium sulphate + calcium chloride + boric acid and potassium sulphate + calcium chloride + boric acid + humic acid on apple. The obtained results showed that potassium sulphate + calcium chloride + boric acid + humic acid combination were the best treatment. This combination had increased N in the two seasons, as compared to the control.

Leaf phosphorus content

Data showed significant variation at all the stages of observations *viz.*, 65, 85 and 105 DAS. At 45 DAS data regarding phosphorus content was non-significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (45 and 65 DAS). At 65 DAS significantly maximum phosphorus content was recorded in T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments. At 85 significantly maximum leaf phosphorus content was noticed in treatments T_{11} (400 ppm HA +50 ppm NAA) followed by T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (300 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments. At 105 DAS treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) significantly increased leaf phosphorus content over control and rest of the treatments.

Phosphorus mobilization in the soil was increased by humic acid by forming humo-phospho complex. This can be easily absorbed by the plants (Balasubramanian *et al*., 1989) [3]. The stimulating activity of humic acid on respiration might have increased the demand for inorganic phosphorus for ATP synthesis, thus leading to increased phosphorus uptake (Smidova, 1960) [30]. It is evident from the data that phosphorus content gradually decreased from 65-85 and 85-105 DAS. It might be because of translocation of leaf phosphorus and its utilization for development of food storage organs (Sagare and Naphade, 1987) [23]. Khalid and Fawy (2011) [13] confirmed that foliar application of 0.1 and 0.2% humic acid significantly increased uptake of P in corn. Kapase *et al*. (2014) [12] reported that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly increased leaf P content in chickpea. Mosa *et al.* (2015) [16] tested ten treatments i.e. control, sprayed with water, K at 2% as potassium sulphate, Ca at 0.2% as calcium chloride, B at 0.2% as boric acid, H.A. at 5% as humic acid, potassium sulphate + humic acid, calcium chloride + humic acid, boric acid + humic acid, potassium sulphate + calcium chloride + boric acid and potassium sulphate + calcium chloride + boric acid + humic acid on apple and reported that combination treatment of potassium sulphate + calcium chloride + boric acid + humic acid was found the best treatment. This combination treatment had increased phosphorus in the two seasons, as compared to the control.

Leaf potassium content

Data were subjected to statistical analysis and were found significant at 65, 85 and 105 DAS. At 45 DAS data regarding K content was non-significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (45 and 65 DAS). At 65 DAS and 85 DAS treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) gave significantly maximum leaf potassium content. At 105 DAS treatments T_{11} (400 ppm HA +50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) expressed their superiority by recording significantly higher potassium content over control and rest of treatments. Treatments T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also found superior over the control.

From the given data it is observed that K content was decreased from 65-85 and 85-105 DAS. Younger plants may be able to uptake nutrients more rapidly than older one. K content in leaf tissue was found higher at 65 DAS stage mainly due to application of nutrients through VCW and it might also be because of relatively higher physiological activities as the plant tissues were younger during this stage. At 85 and 105 DAS K content in leaves decreased. It might be due to translocation of leaf K and its utilization for grain development in linseed. Kapase *et al*. (2014) [12] applied different concentrations of VCW and NAA alone and in combination and found that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced leaf K content in chickpea. Mosa *et al.* (2015) [16] checked ten treatments i.e. control, sprayed with water, K at 2% as potassium sulphate, Ca at 0.2% as calcium chloride, B at 0.2% as boric acid, H.A. at 5% as humic acid, potassium sulphate + humic acid, calcium chloride + humic acid, boric acid + humic acid, potassium sulphate + calcium chloride + boric acid and potassium sulphate + calcium chloride + boric acid + humic acid on apple and opined that combination treatment of potassium sulphate + calcium chloride + boric acid + humic acid was found superior treatment. This combination treatment had increased K in the two seasons, as compared to the control.

Protein content in seed

Data showed significant variation by the application of HA and NAA. Significantly maximum seed protein was recorded in treatment of foliar application of T_{11} (400 ppm HA + 50 ppm NAA) followed by application of treatments T_{10} (400 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) when compared with control and rest of the treatments. N is the constituent of protein hence, increase in N content ultimately resulted in increase in protein content in grains of pigeonpea in the present investigation. Major part of N is accumulated in the seed during grain filling stage. Nitrogen is key component in mineral fertilizers and has more influence on plant growth, appearance and fruit production / quality than any other element. It affects the absorption and distribution of other essential elements. Foliar application of HA through VCW and NAA increases the uptake and availability of nutrients and its further assimilation for biosynthesis of protein. This might be the reasons for increased protein content in seed in the present investigation. The mode of action of humic acid on plant growth can be divided into direct and indirect effects as it affects the membranes resulting in improved transport of nutritional elements, enhanced photosynthesis, and solubilization of micro nutrients which ultimately enhances the protein synthesis. Venkata Ramana *et al.* (2010) [33] used different concentrations (100, 150, 200 ppm) of VCW and CDW at 25 and 35 days after pruning in mulberry and found that 20 ppm VCW treatment significantly increased the protein content in mulberry leaves. Saurhan *et al*. (2011) [26] reported that HA treatments (control, soil 10%, seeds 100%, leaves 100%, Soil 50% + seeds 50%, Soil 50% + leaves 50%, Seeds 50% + leaves 50% and seed 33% + Soil 33% + leaves 33% fertilizations) increased crude protein concentration in common millet (*panicum miliaceum*). While the highest crude protein concentration (13.43%) was obtain from seeds 33% + Soil 33% + leaves 33% fertilization. Kapase *et al*. (2014) [12] noticed that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly increased seed protein content in chickpea.

Number of pods plant^{-1}

Data regarding number of pod plant^{-1} are presented in table 2. Significant and highest number of pods plant^{-1} was recorded in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Treatments T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) also exhibited significantly more number of pods plant^{-1} when compared with other remaining treatments and control.

Number of seeds pod^{-1}

Data regarding number of seeds pod^{-1} gave significant variation and same are presented in table 2. Number of seeds pod^{-1} increased significantly and it was maximum in treatments T_{11} (400 ppm HA + 50 ppm NAA) and T_{10} (300 ppm HA + 50 ppm NAA) in a descending manner when compared with remaining treatments and T_1 (control). Similarly treatments T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) showed their significance over control (T_1). Higher number of seeds pod^{-1} might be due to the indirect positive effect of HA on chlorophyll content. The increase in chlorophyll content promotes photosynthetic activities which, in turn, diverts more photo-assimilates towards higher number of seeds pod^{-1} (Nardi *et al*., 2002) [18].

Test weight

Data obtained about test weight are given in table 2. The 100 seed weight was significantly maximum in treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by the treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA). Treatments T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also significantly increased 100 seed weight when compared with remaining treatments and control (T_1).

Application of humic acid as a foliar spray increases the seed weight due to better mobilization of nutrients to seed. Nardi *et al.* (1999) [19] found that the biological activity of humic acid was attributed to their chemical structure and their functional groups, which could interact with harmonic-binding proteins in the membrane system, evoking a hormone like response. Waqas *et al.* (2014) [34] conducted triplicate field experiment to evaluate the different concentrations of humic acid on yield components of mungbean. The treatments comprised of three methods of humic acid application i. e. seed priming with 0% (water soaked), 1%, 2% humic acid solution, foliar spray with 0.01%, 0.05% and 0.1% humic acid solution and soil application of humic acid 3 kg ha^{-1} resulted significantly higher number of pods plant^{-1}, 1000 grain weight and grain yield. A field experiment was carried out by Nadimpoor and Mani (2015) [17] to investigate the effect of different levels of humic acid and harvest time of forage on the forage and grain yield of dual purpose barley. Data showed that yield contributing parameters *viz*., grain yield, number of spikes unit^{-1} area, number of grains spike^{-1} significantly increased with the 1000 ppm humic acid and the forage harvest at the beginning of stem elongation were superior to the other treatments in dual purpose cultivation (forage + grain).

Seed yield plant^{-1} (g) and plot^{-1} (kg)

Data regarding seed yield plant^{-1} and plot^{-1} are given in table 2. Seed yield is the economic yield which is final results of physiological activities of plants. Economic yield is that part of biomass that is converted into economic product (Nichiporvic, 1960) [20]. Significantly maximum seed yield plant^{-1} and plot^{-1} was recorded in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA) in a descending manner when compared with control and rest of the treatments. Treatments T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also exhibited superiority over control (T_1).

The growth hormone reduces flower drop, abscission of flower and ultimately increased seed yield and biomass production in pigeonpea. Hormones play a key role in the long distance movement of metabolites in plant. Auxin has effect on phloem transport. The metabolites and nutrients are moved from leaves and other parts of the plant into the fruits. (Seth and Wareing, 1967) [27]. Humic acid had been shown to stimulate plant growth and consequently yield by acting on mechanisms i.e. cell respiration, photosynthesis, protein synthesis, water nutrient uptake and enzyme activities (Chen *et al*., 2004) [7] which results into increase in various growth characters *viz*., plant height, number of branches plant^{-1}, leaf area, total dry matter production which are correlated with increase in the number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight and seed yield plant^{-1}. These might be the reasons responsible for increase in yield of pigeonpea in the present investigation. A field experiment was carried out by Waqas *et al.* (2014) [34] to test the different concentrations of humic acid on yield components of mungbean. The treatments comprised of three methods of humic acid application i. e. seed priming with 0% (water soaked), 1%, 2% humic acid solution, foliar spray with 0.01%, 0.05% and 0.1% humic acid solution and soil application of humic acid 3 kg ha^{-1} and reported significantly more number of pods plant^{-1}, 1000 grain weight and grain yield. Nadimpoor and Mani (2015) [17] investigated the effect of different levels of humic acid and harvest time of forage on the forage and grain yield of dual purpose barley. Data revealed that yield contributing parameters viz., grain yield, number of spikes unit^{-1} area, number of grains spike^{-1} significantly enhanced with the 1000 ppm humic acid and the forage harvest at the beginning of stem elongation.

Table 1: Effect of humic acid through vermicompost wash and NAA on chemical and biochemical parameters

Treatments	Leaf chlorophyll content (mg g^{-1})				Leaf nitrogen content (%)				Leaf phosphorus content (%)			
	45 DAS	65 DAS	85 DAS	105 DAS	45 DAS	65 DAS	85 DAS	105 DAS	45 DAS	65 DAS	85 DAS	105 DAS
T_1 (control)	1.131	1.243	1.162	0.772	2.867	2.816	2.763	2.441	0.319	0.332	0.324	0.272
T_2 (300 ppm HA)	0.958	1.267	1.242	0.811	2.822	2.871	2.822	2.518	0.285	0.346	0.331	0.283
T_3 (400 ppm HA)	0.987	1.291	1.263	0.829	2.829	2.965	2.896	2.717	0.284	0.369	0.346	0.294
T_4 (500 ppm HA)	1.193	1.261	1.230	0.792	2.695	2.846	2.792	2.447	0.281	0.338	0.327	0.275
T_5 (25 ppm NAA)	1.021	1.298	1.269	0.833	2.396	3.097	3.021	2.849	0.312	0.374	0349	0.297
T_6 (50 ppm NAA)	1.068	1.332	1.271	0.835	2.812	3.104	3.057	2.851	0.314	0.383	0.351	0.304
T_7 (300 ppm HA + 25 ppm NAA)	1.099	1.342	1.333	0.879	2.173	3.685	3.505	3.186	0.284	0.391	0.363	0.319
T_8 (400 ppm HA + 25 ppm NAA)	0.947	1.368	1.378	0.932	2.681	3.877	3.746	3.224	0.279	0.407	0.374	0.325
T_9 (500 ppm HA + 25 ppm NAA)	0.991	1.337	1.291	0.861	2.662	3.326	3.146	2.872	0.327	0.389	0.358	0.308
T_{10} (300 ppm HA + 50 ppm NAA)	1.180	1.453	1.395	0.943	2.769	4.413	4.266	3.876	0.282	0.428	0.382	0.331
T_{11} (400 ppm HA + 50 ppm NAA)	0.952	1.497	1.404	0.976	2.641	4.471	4.293	4.116	0.271	0.432	0.397	0.346
T_{12} (500 ppm HA + 50 ppm NAA)	1.062	1.442	1.380	0.933	2.634	4.390	4.105	3.852	0.303	0.417	0.378	0.327
SE (m) ±	0.067	0.034	0.033	0.028	0.173	0.146	0.106	0.103	0.0186	0.0162	0.0129	0.0113
CD at 5%	-	0.103	0.098	0.083	-	0.516	0.316	0.307	-	0.0483	0.0384	0.0337

Table 2: Effect of humic acid through vermicompost wash and NAA on leaf potassium content, seed protein content and yield contributing parameters.

Treatments	Leaf potassium content (%)				Seed protein content (%)	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (kg)
	45 DAS	65 DAS	85 DAS	105 DAS						
T_1 (control)	0.849	0.758	0.639	0.538	19.28	106.35	3.23	7.13	16.37	1.63
T_2 (300 ppm HA)	0.827	0.772	0.648	0.587	21.16	113.32	3.58	7.51	17.01	1.70
T_3 (400 ppm HA)	0.831	0.777	0.651	0.593	21.76	118.03	3.61	7.93	17.32	1.73
T_4 (500 ppm HA)	0.853	0.771	0.643	0.581	20.89	112.96	3.49	7.49	16.51	1.65
T_5 (25 ppm NAA)	0.844	0.787	0.703	0.611	22.43	118.26	3.63	8.67	18.36	1.83
T_6 (50 ppm NAA)	0.853	0.826	0.718	0.619	22.46	122.19	3.68	9.19	18.78	1.87
T_7 (300 ppm HA + 25 ppm NAA)	0.910	0.841	0.727	0.713	22.58	126.65	3.92	9.33	18.97	1.89
T_8 (400 ppm HA + 25 ppm NAA)	0.836	0.853	0.733	0.717	22.61	127.81	4.02	10.18	19.52	1.95
T_9 (500 ppm HA + 25 ppm NAA)	0.856	0.837	0.721	0.647	22.57	122.76	3.69	9.26	18.86	1.88
T_{10} (300 ppm HA + 50 ppm NAA)	0.853	0.867	0.758	0.736	22.74	133.16	4.58	10.76	20.37	2.03
T_{11} (400 ppm HA + 50 ppm NAA)	0.813	0.882	0.761	0.741	22.86	142.27	4.93	10.92	20.86	2.08
T_{12} (500 ppm HA + 50 ppm NAA)	0.936	0.859	0.746	0.727	22.71	131.47	4.17	10.59	20.21	2.02
SE (m) ±	0.054	0.0204	0.0231	0.0228	0.863	4.498	0.158	0.451	0.504	0.0432
CD at 5%	-	0.061	0.069	0.068	2.578	13.423	0.471	1.347	1.504	0.129

References

1. Arsode SV. Influence of foliar sprays of humic acid through cowdung wash and NAA on growth and yield of mustard. M. Sc. (Agri.) thesis (unpub.) submitted to Dr. P. D. K. V. Akola, 2013.
2. Ameri A, Tehranifar A. Effect of humic acid on nutrient uptake and physiological characteristic of *Fragaria ananassa* var: Camorasa. J Biol. Environ. Sci. 2012; 6(16):77-79.
3. Balasubramanian P, Chandrasekaran S, Govindasamy R. Effect of humic acid on the yield, dry matter production and nutrient content of blackgram (*Vigna mungo* L. Hepper). Proc. National Seminar on humus acids in agriculture, Annamalai University, 1989, 145-152.
4. Bruinsma JA. comment on spectrophotometric determination of chlorophyll. Bio-chem., Bio-Phy., Acta. 1982; 52:576-578.

5. Chaturvedi SK, Ali M. Poor man's meat needs fresh fillip; The Hindu Survey of Indian Agriculture. 2002, 63-69.
6. Chen Y, Solovitch T. Effect of humic substances on plant growth. ISHS Acta Horti, 2003, 221.
7. Chen Y, Nobili M De, Aviad T. Stimulatory effect of humic acid substances on plant growth. In: Magdoff FR, Weil RR, (Eds.) Soil Organic Matter in Sustainable Agriculture. CRC Press New York, USA, 2004. 103-129.
8. Faris DG, Singh U. Pigeonpea: nutrition and products In the pigeonpea (Nene, Y.L., Hall, S.D., and Sheila, V.K., Eds.) Wallingford, Oxon, UK: CAB International, 1990, 401-434.
9. Gardner FP, Pearce RB, Mitchell RL. Transport and partitioning. In physiology of crop plants. 2nd Ed. Scientific publishers, Jodhpur. 1988, 58-95.
10. Haripriya K, Poonkodi P. Role of organic mulches and foliar nutrition on changes, nutrient uptake and residual soil fertility in tuberose. Adv. Plant Sci. 2005; 18(1):175-178.
11. Jackson ML. Soil Chemical analysis, Printice Hall of India Pvt. Ltd. New Delhi, 1967, 25-28.
12. Kapase PV. Effect of foliar sprays of humic acid through vermicompost wash with NAA on growth and yield of chickpea. M. Sc. (Agri.) thesis (unpub.) submitted to Dr. P. D. K. V. Akola, 2014.
13. Khalid H, Fawy HA. Effect of different levels of humic acids on the nutrient content, plant growth and soil properties under condition of salinity. J. Soil and Water Res. 2011; 6(1):21-29.
14. Lawn RJ, Troedson RJ. Pigeonpea: Physiology of Yield Formation in the Pigeonpea edited by Y. L. Nene, Susan D. and V. K. Sheila; CAB international, Wallingford, UK, 1990, 190.
15. Mac Carthy P, Clapp CE, Malcom RL, Bloom PR. Humic substances in soil and crop sciences: selected readings. Am. Soc. Agron. and Soil Sci. Soc. Am. Madison, W.I, 2001.
16. Mosa WFAEG, El-Megeed NAA, Paszt LS. Effect of the foliar application of potassium, calcium, boron, and humic acid on vegitative growth, fruit set, leaf mineral, yield and fruit quality of 'Anna' apple trees. American J. Experimental Agril. 2015; 8(4):224-24. Article no. AJEA.:166.
17. Nadimpoor S, Mani M. The effect of humic acid application and harvest time of forage on grain and forage yield of dual purpose barley. Indian J. Fundamental appli. L. Sci. 2015; 5(1):231-237.
18. Nardi S, Pizzeghello D, Muscolo A, Vianello A. Physiological Effects of Humic Substances on Higher Plants. Soil Biol. Biochem. 2002; 34:1527-1536.
19. Nardi S, Pizzeghello D, Renero F, Muscobo A. Biological activity of humic substances extracted from soil under different vegetation cover. Commun. Soil Sci. Plant Anal. 1999; 30:621-634.
20. Nichiporvic AA. Photosynthesis and the theory of obtaining high yields. Fld. Crop Abstr. 1960; 13:169-175.
21. Panse VG, Sukhatme PV. Statistical methods for agriculture workers. ICAR, New Delhi 2nd 1954: 63-66.
22. Poonkodi P. Phosphorus use efficiency in black gram with pressmud. Adv. Plant Sci. 2003; 17(1):239-241.
23. Sagare BN, Naphade KT. Effect of hormone on yield, economics and nutrients uptake by groundnut (*Arachis hypogea* L.). P.K.V. Res. J. 1987; 11(1):19-21.
24. Salih HO. Effect of foliar fertilization of Fe, B and Zn on nutrient concentration and seed protein of cowpea "*Vigna unguiculata*. J. Agric. Vet. Sci. 2013; 6:42-46
25. Salunkhe DK, Kadam SS, Chavan JK. Post harvest Biotechnology of legumes, CRC press Boca Raton Florida, 1985, 35-160.
26. Saruhan V, Kusvuran A, Babat S. The effect of different humic acid fertilization on yield and yield components performances of common millet (*Panicum miliaceum* L.). Sci. Res. Essays. 2011; 6(3):663-669.
27. Seth AK, Wareing PF. Hormone directed transport of metabolites and its possible role in plant sensescence. J. Expt. Bot. 1967; 18(54):65-77.
28. Sharma R, Singh G, Sharma K. Effect of triacontanol, mixatol and NAA on yield and it's components in mung bean. Indian J agric. 1989; 3(1):59-60.
29. Shweta A, Yadav K, Kiran Kumar, Mamta Sharma. Vermiwash a liquid biofertilizer. Uttar Pra. J 2005; 25(1):97-99.
30. Smidova M. The influence of humic acid on the respiration of plant roots. Biol. Plant. 1960; 2:152-164.
31. Somichi Y, Doughlus SY, James AP. Laboratory manual. Physiological studies in rice analysis for total nitrogen (organic N) in plant tissue. The inter. Res. Instti. Los Banos, Languna, Phillipine: 1972, II.
32. Sreerama YN, Sashikala VB, Pratape VM. Variability in the distribution of phenolic compounds in milled fractions of chickpea and horse gram: Evaluation of their antioxidant properties. J. Agric. Food Chem. 2010; 58:8322-30.
33. Venkatramana P, Narsimhamurti B, Krishna Rao JV, Kamble CK. Efficacy of foliar sprays of vermiwash and cowdung wash on biochemical and yield attributes and yield of mulberry. Karnataka J. Agric. Sci. 2010: 23(2):358-360.
34. Waqas M, Ahmad B, Arif M, Munsif F, Khan AL, Amin M *et al*. Evaluation of humic acid application methods for yield and yield components of mungbean. American J. Plant Sci. 2014; 5:2269-2276.