 

# Efficacy of exogenous application of 2, 4-Dichlorophenoxyacetic acid (2, 4-D) on growth and yield of mungbean (*Vigna radiata* L.)

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**ABSTRACT**

The growth and yield promotion of mungbean in response to the use of 2, 4-Dichlorophenoxy acetic acid (2, 4-D) was investigated through a pot study which was arranged in the wire house of Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. The study was comprised of five treatments and three replications (control, 0.2 ppm 2, 4-D, 0.5 ppm 2, 4-D, 0.8 ppm 2, 4-D, and 1 ppm 2, 4-D). The suggested dose of Nitrogen, Phosphorus and Potassium (NPK) was applied at the amount of 20, 60 and 25 kg $ha^{-1}$ added as Urea, DAP and SOP, respectively at sowing time. The data regarding growth (plant height, root and shoot length, root and shoot fresh and dry weight, and total biomass), yield (grain weight, number of grains $plant^{-1}$) and NPK analysis in plants and soil was recorded and statistically analyzed. The response of exogenous application of 2, 4-D was significant at all levels in improving the performance of all the growth parameters and yield as compared to untreated control treatment. Maximum performance of all the parameters was recorded at 0.8 ppm application of 2, 4-D. As the concentration of 2, 4-D increased the development of plants also showed positive effect but up to 0.8 ppm application after that it started to decrease which showed that at higher concentrations 2, 4-D acts as growth retardant.

## 1. INTRODUCTION

Legumes are the third largest and one of the most important plant family. Among legumes, mungbean (*Vigna radiata* L.) is an important pulse crop belongs to family leguminoseae commonly known as green gram and famous in number of countries including Pakistan. The production of pulse crops in the past few years has declined unluckily in almost all conventionally pulse growing countries. Pakistan and South Asian countries are the world's major producers and users of pulses including mainly mungbean, chickpea and pigeon pea. The vicinity under mungbean crop in Pakistan is 136.1 thousand hectares and producing about 89.3 thousand tons of grains annually. This low grain yield of the crop i.e. 656.13 kg $ha^{-1}$ on an average can be enhanced by proper utilization of plant growth regulators and genetic potential of microbial and plant species (Anonymous, 2013).

The effect of plant growth regulators (promoters, retardants and inhibitors) in various physiological and biological processes in plants is well known, which enables a rapid change in the phenotype of the plant. Growth regulators are known to affect seed germination, vegetative growth, flowering, and fruit set, seed development, fruit ripening and yield. Further, the physicochemical quality of the crop is also influenced by growth regulators (Hobbie, 1998).

Recent reaches shows that endogenous growth substances are involved in many processes which lead to growth and development. Plants have also been shown to respond to exogenous application of plant growth regulators. Considering their role in plants, plant growth regulators have been designated as magic chemicals which bring about an unprecedented growth and help in removing and circumventing many of the barriers imposed by genetics and environment. Crop yield is a complex heritable character influenced by many morphological and physiological characters of plant interacting with environment. An attempt has been made to present the impact of plant growth regulators on plant development and growth (Teale *et al*., 2006).

Plant growth regulators show a fundamental part in development promotion and yield of crops. Auxins are of supreme importance among the five major classes of PGRs. In 1880 Charles Darwin indicated that some plant growth responses are governed by a matter which translocate its effect from one part of the plant to the other part (Kevin, 2003). After several decades, this matter was termed as Auxin and it was identified as indol-3-acetic acid (Kevin, 2003; Spaenpen *et al*., 2007). Although these are synthesized within the plant bodies but its exogenous application renders a considerable response (Frankenberger and Arshad, 1991; Khalid *et al*., 2006). Rhizosphere microbes are a natural source of PGRs. These microorganisms release a very small quantity of PGRs in the rhizosphere but even in these small quantities, the PGRs are very efficient in promoting plant growth and development. Auxin promotes growth rate, flowering, fruit setting and fruit initiation and also involves in nodulation process. Auxin production is more active in that soil where substrate and microorganisms are in abundance (Rossi *et al*., 1984). Latter on it was found that not only plants but microorganisms also synthesize IAA (Kevin, 2003; Hontzeas *et al*., 2004; Leinhos, 1994). Many strains of microbes have role in nitrogen fixation as well as in plant growth regulators production. Such strains not only provided benefit to their host plant but also prove effective for other plants (Farah *et al*., 2004; Hontzeas *et al*., 2004; Arshad and Frankenberger, 1998; Rajesh, 2005). These microorganisms usefully effects the plant growth by producing indol-3-acetic acid which have great role in uptake of nutrients by plant roots (Kevin, 2003; Khalid *et al*., 2004; Belimov *et al*., 2001).

Auxins are used commercially for enhancing crop production and regulation plant growth and development fast growth such as shoot tissue, young leaves and emerging seeds, elongation but do stimulate lateral root growth increase seed weight and pod number. However, auxin application increase seed weight, pod numbers or seed yield but this established on varietals sensitivity and accurate application timing. Natural occurring Auxin in plant (IAA) could also increase the grain-filling and mobilization significantly over control (Ray and Choudhuri, 1981).

2, 4-Dichlorophenoxy acetic acid (2, 4-D) is recognized as synthetic Auxin, at lower concentrations it acts as plant growth regulator and at higher concentrations it act as growth retardant. It is widely used at higher concentrations as herbicide for broad leave weeds. It is known to initiate several physiological and biochemical processes which influence plant growth, development, flowering, and fruit set, fruit ripening and finally seed yield and quality (Campanoni and Nick, 2005).

## 2. MATERIALS AND METHODS

A pot experiment was conducted in a rain protected wire house at the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during the month of July-October, 2012. The experiment was designed to evaluate the effect of 2, 4-D on growth, yield, nodulation and early flower induction in mungbean (*Vigna radiate* L.).

Bulk soil samples were collected from Agronomy field, UAF. Soil was air-dried and ground to pass through 5.00 mm sieve. The soil was thoroughly mixed for homogenized and uniform experimental material. A portion of prepared soil was analyzed for various physico-chemical properties of soil. To each of 15 plastic pots, 10 kg of the soil was transferred. Pots were arranged according to planned design (CRD). There were five treatments and three replications of each treatment selected for the study. The mungbean (NM 98) was grown and applies different treatments of 2, 4-D. Various combinations of treatment factors are shown below:

T1 = NPK
T2 = T1+ 0.2 ppm 2, 4-D
T3 = T1 + 0.5 ppm 2, 4-D
T4 = T1+ 0.8 ppm 2, 4-D
T5 = T1 + 1 ppm 2, 4-D

Uniform rates of N, P and K were added @ 20 kg N, 60 kg P and 25 kg K $ha^{-1}$ in the form of Urea, DAP and SOP. Before sowing of mungbean seed, $1^{st}$ of all seeds of mungbean were kept for germination at dark place for

 

3-4 days. Before keeping for germination 1st socked the seeds in 10 mM solution of $CaSO_4$ and then kept for germination at dark place.

Crop was harvested after maturity. Shoot samples were removed from each pot and were collected in separate bags that were labeled according. The soil from each pot was washed away to collect root samples. Both shoot and root samples were washed with distilled water. The flowering and nodule data was also collected at their flowering stage. Sun dried samples were oven dried at 70 $^0$C in a forced air oven to a constant weight. The shoot and root dry matter was collected. Oven dried samples were finally ground in sample grinder (IKA Werke) fitted with stainless steel blades. Samples were stored in paper bags for further analysis. Various treatments of 2, 4-D application will be arranged according to CRD in three replications. Plant growth data will be statistically analyzed by using analysis of variance technique. Significant treatment means will be separated by least significant test (LSD).

## 3. RESULTS AND DISCUSSION

### 3.1. Effect of 2, 4-D on growth related characteristics

#### 3.1.1. Plant Height

Auxin are reported to promote growth at low concentration by enhancing the better utilization of photosynthetic process. It was observed that highly significant differences appeared among plant heights on exposure to different concentrations of 2, 4-D. Maximum plant height was reported in treatment T4 (47.33 cm) at which 2, 4-D was used @ 0.8 ppm. The minimum value of mean was noticed in T1 (30 cm) that is control without any treatment, with only recommended dose of N, P and K fertilizer (Table 1). The percentage of increase in T4 was 35.2% and 6.4% as compared to treatments T2 and T3 respectively. The increase in plant height inT4 was 9.2% as that of T5 at which 2, 4-D was applied @ 1 ppm. The foliar application of 2, 4-D also showed great rise in plant height. The increase in plant height was 16.7% and 48.3% in treatments T2 and T3 respectively as compared to untreated control. Production of phytohormone like auxin in rhizosphere is responsible for increasing growth parameters like plant height and plant biomass (Zahir *et al*, 2010).

#### 3.1.2. Root Length

The data revealed that the application of 2, 4-D caused maximum increase in root length of plants as compared to untreated control. The maximum root length was noticed in treatment T4 (23.33 cm), compared to control plants (14.33 cm) (Table 1). The treatments T5 and T4 showed insignificant results with each other's but their results are highly significant as compared to control plants. The percentage of increase in T2 and T3 was 20.9% and 39.5% respectively as compared to control plants that contained only recommended dose of N, P and K fertilizer. The treatment T5 had 48.8% increases in root length, compared to control. The percentage of increase of root length in T4 was 34.6%, 16.7% and 9.3%, compared to T2, T3 and T5 respectively. Foliar application of 2, 4-D increased all growth parameters such as plant height, fresh and dry weights of plant and root length of plants (Poudel, 2006).

#### 3.1.3. Shoot Fresh & Dry Weight

The quantitative statistical data regarding shoot fresh and dry weight showed considerable improvement by the application of all treatments as compared to untreated. The maximum increase in shoot fresh and dry weight was observed in treatment T4 which was 44.36g & 7.93g respectively (Table 1). The percentage of increase in shoot fresh weight in treatment T4 was 22.1% and 14.2% as compared to T2 and T3 respectively. The minimum mean value of shoot fresh weight (31.7) was observed in control where only recommended dose of N, P and K fertilizer was used without any treatment. The percentage of increase in T4 was 8.2% as compared to treatment T5. Analysis of variance of data showed that shoot fresh weight is insignificant between treatments T5 and T4

Table 1. Effect of 2, 4-D on growth related characteristics of mungbean

| | Plant height (cm) | Root length (cm) | Shoot fresh weight (g) | Shoot dry weight (g) | Root fresh weight (g) | Root dry weight (g) | No. of nodules per plant | Days to 1st flowering | No. of flowers per plant |
|---|---|---|---|---|---|---|---|---|---|
| T1 | 30c | 14.33d | 31.66d | 5.36d | 8.36c | 3d | 10c | 41 | 40.33d |
| T2 | 35b | 17.33cd | 36.33c | 6.16c | 10.5b | 3.4c | 12bc | 38.33 | 45.33c |
| T3 | 44.5a | 20bc | 38.83bc | 6.86b | 11.3ab | 3.7b | 13ab | 36 | 50b |
| T4 | 47.33a | 23.33a | 44.36a | 7.93a | 12.83a | 4.13a | 15a | 33 | 62.66a |
| T5 | 43.33a | 21.33ab | 41ab | 7.06b | 12.33ab | 3.9ab | 13ab | 35.33 | 53.33b |
| LSD | ** | ** | ** | ** | ** | ** | * | ** | ** |

*Significant (P<0.05), **Highly Significant (P<0.01)

but all treatments had significant increase in as compared to untreated control plants. Percentage of increase of shoot dry weight in T4 was 28.6% and 15.5% as compared to the T2 and T3 respectively. The percentage of increase in T4 was also higher (123%) as that of T5 at which 2, 4-D was used @ 1 ppm. It indicated that at lower level 2, 4-D increased shoot dry weight at higher levels it acted as growth retardant. Over all data showed that all treatments respond well regarding shoot dry weight as compared to control. Our results are similar to the findings of other researchers that 2, 4-D caused to increase the shoot fresh and dry weight in crop plants (Aziz *et al.,* 2010). The study indicated that 2, 4-D is important in tomato production to increase shoot fresh and dry weight at lower concentrations, at higher concentrations it decreased shoot fresh and dry weight (Gelmesa *et al*., 2012). By the application of 2, 4-D vegetative growth of the plants increased and shoot fresh and dry weight were also increased (Tuan *et al*., 2013).

### 3.1.4. Root Fresh & Dry Weight

The exogenous application of 2, 4-D produced significant results in increasing root fresh and dry weight as indicated from the analysis of variance. The highest increase in root fresh and dry weight was reported in treatment T4 at which 2, -D was applied @ 0.8 ppm. The minimum value of mean was noticed in T1 8.3g and 3g of root fresh and dry weight respectively that is control without any treatment, with only recommended dose of N, P and K fertilizer. By the foliar application of 2, 4-D root fresh and dry weight increased up to treatment T4 after that it decreased in treatment T5. It indicated that at higher concentrations 2, 4-D decreased root growth. The increase in root fresh weight in T4 was 22.2%, 13.5% and 4% respectively as compared to treatments T2, T3 and T5. The increase in root dry weight in T4 was 21.6%, 9.7% and 6% respectively as compared to treatments T2, T3 and T5.The data showed that all the treatments had considerable positive impact on root fresh weight, compared to untreated control plants. Our study is parallel to the works of other scientists that root fresh and dry weight increased by increasing concentration of 2, 4-D but up to a certain level (Markose *et al*., 2006). According to Aziz *et al.* (2010) root fresh and dry weight increased by increasing concentration of 2, 4-D but up to a certain level.

### 3.1.5. No. of Nodules per Plant

The data regarding no. of nodules per plant after treatment applications was subjected to statistical analysis and results are presented in Table 1.It was indicated by the analysis of variance that the effect on the no. of nodules per plant upon the application of 2, 4-D was significant. Maximum no. of nodules (15) was observed in treatment T4 at which 2, 4-D was applied @ 0.8 ppm. All treatments showed great improvement in nodule formation, compared to control. The percentage of increase in nodule formation at treatment T4 was 25%, 15.4% and 15.3% as compared to treatments T2, T3 and T5 respectively. Statistical data revealed that all treatments had significant positive impact on nodule formation in mungbean, compared to untreated control plants. The percentage of increase in T2, T3 and T5 was 20%, 30% and 30% respectively as compared to control plants. The minimum mean value regarding number of nodules per plant was observed in control T1 (10) with only recommended dose of N, P and K fertilizer. Previous study showed that nodule formation was found to be superior by the action of 2, 4-D (Azam and Lodhi, 2001). By the application of 2, 4-D in wheat paranodules were formed which fix more nitrogen as compared to control (Tchan *et al.,* 1991). Perigio *et al*. (1991) reported that by the application of 2, 4-D more and larger nodules were formed, compared to control.

### 3.1.6. Flowering

The data regarding flowering such as number of flowers per plant and days to first flowering is depicted in Table 1. Total number of flowers per plant was increased with the foliar application of 2, 4-D. Maximum number of flowers (62) was obtained from plants which were treated with 0.8 ppm 2, 4-D. Minimum number of flowers (40) was observed from control plants. The other treatments also shows increase in number of flowering but maximum was observed in T4. In case of days to first flowering 2, 4-D also shows positive impact. The plants treated with 2, 4-D shows early flowering. The data collected subjected to statistical analysis which shows that control treatment takes maximum days (41) to first flowering. From Table 1 it is indicated that plants of treatment T4 shows less days (33) to first flowering as compared to control and other treatments. The treatments T4 and T5 showed insignificant results with each other's but their result are highly significant as compared to control plants. The percentage of increase of flowering in T4 was 38.2%, 25.3% and 17.5%, compared to T2, T3 and T5 respectively. 2, 4-D increased all growth parameters (plant height, fresh and dry weights of plant and number of flowers per plant) at both vegetative and flowering stages (Uddain *et al.,* 2009). Our results are also parallel to the results of Resmi and Gopalakrishnan (2004) on apple and Kannan *et al*. (2009) on paprika plants. Ricard *et al*. (1990) stated that application of 2, 4-D on potato caused great increase in flowering parameters and increase the percentage of capsule set.

### 3.1.7. No. of Pods per Plant

The data regarding No. of pods picked after the harvesting of crop was subjected to statistical analysis and results are presented in the Table 2. It was shown from the data that the application of varying concentrations of 2, 4-D caused increase in the number of pods. The highest increase in formation of pods was reported in treatment T4 (47.33) at which 2, 4-D was applied @ 0.8 ppm. The minimum value of mean (31.66) was noticed in T1 that is control without any treatment, with only recommended dose of N, P and K fertilizer. The percentage of increase in T4 was 35.2% and 16.4% as compared to treatments T2 and T3 respectively. The increase in pod formation inT4 was 11% as that of T5 in which 1 ppm 2, 4-D was applied. It indicated that at higher concentrations 2, 4-D decreased pod formation. The foliar application of 2, 4-D had resulted in great increase in pod formation. The increase in formation of pods was 49.5%, 28.4% and 10.5% in treatments T4, T3 and T2 respectively as compared to untreated control. By the foliar application of 2, 4-D number of pods per plant increased up to treatment T4 after that it decreased as in treatment T5. It indicated that at higher concentrations 2, 4-D decreased number of pods per plant. The data showed that all the treatments had considerable positive impact on pod formation, compared to control plants. Previous studies indicated that 2, 4-D caused an increase in number of pods per plant in chilli (Chaudhary *et al*., 2006). Production of phytohormone like auxin in rhizosphere is responsible for increasing growth parameters like number of pods per plant, number of grains per pod and plant biomass (Zahir *et al*., 2010).

### 3.1.8. Pod Length

It was evident from the statistical analysis that the effect of the application of 2, 4-D was significant in increasing the pod length. Pod length of mungbean plants was considerably increased by all treatments, compared to control plants. The maximum increase in pod length (13.66 cm) was recorded at treatment T4 at which 2, 4-D was used @ 0.8 ppm and at this treatment percentage of increase was 24.2%, 17.1% and 13.8% as compared to treatments T2, T3 and T5 respectively. The treatments T6 and T5 showed 25% and 31% increase in pod length respectively as compared to control. The lowest mean value (9 cm) was observed in control. The increase in pod length was 22.2%, 29.6%, 51.8 and 33.3% in treatments T2, T3, T4 and T5 respectively as compared to untreated control. By the foliar application of 2, 4-D number of pod length increased up to treatment T4 after that it decreased as in treatment T5. It indicated that at higher concentrations 2, 4-D decreased pod length. Our study is supported by the findings of other scientists. 2, 4-D has great role in root elongation (Chaudhary *et al*., 2006). 2, 4-D is prominent factor in pod elongation. Singh *et al*. (1990). Pod length increased by increasing concentrations of 2, 4-D but up to a certain level (Biradar, 1999).

Table 2. Effect of 2, 4-D on Yield related characteristics of mungbean

| | No. of pods per plant | Pod length (cm) | Weight of pod (g) | 1000 grain weight (g) | No. of grains per pod | No. of grains per plant |
|---|---|---|---|---|---|---|
| $T_1$ | 31.66c | 9c | 5.33d | 42.66d | 5.66d | 187.66d |
| $T_2$ | 35c | 11bc | 5.93c | 45cd | 7.33c | 255.33c |
| $T_3$ | 40.66b | 11.66ab | 6.43b | 47.66bc | 7.66b | 317.33b |
| $T_4$ | 47.33a | 13.66a | 7.06a | 51.33a | 9.66a | 391.67a |
| $T_5$ | 42.66b | 12ab | 6.82ab | 48.66ab | 9ab | 320.33b |
| LSD | ** | ** | ** | ** | ** | ** |

*Significant (P<0.05), **Highly Significant (P<0.01)

3.2. Effect of 2, 4-D on Yield related characteristics

3.2.1. Weight of pod with grains

Data showed the significant effect of 2, 4-D on weight of pod with grains. Highest increase in weight of pod was observed in treatment T4 (7.06 g) that was 19% and 9.7% as compared to $T_2$ and $T_3$ respectively. Improvement in pod weight in case of treatments $T_2$, $T_{3,}$ $T_4$ and $T_{5,}$ was 11.2%, 20.6%, 32.3% and 28% respectively, compared to control where only recommended dose of N, P and K fertilizer was used. The presented data reported that overall effect of all treatments showed great improvement in pod weight as compared to control with only recommended dose of N, P and K fertilizers. Previous studies indicated that plant growth promoting substance (2, 4-D) is responsible for increase in pod weight and improvement of yield in crop plants (Chaudhary, 2004). These results are also parallel to the reports of Rajamani *et al*. (1990) and Perigio *et al*. (1991). They reported that 2, 4-D increased the yield of plants.

3.2.2. 1000 grain weight

Significant differences were observed among different treatments Table 2. The plants which received 2, 4-D @ 0.8 ppm gave maximum grains weight (51.33 g) and increase was 20.3% higher than that of control. The presented data statistically expressed that all the treatments caused considerable increase in1000 grain weight as compared to control. The maximum grains weight in T4 was 14%, 7.7% and 5.4% as compared to T2, T3 and T5 respectively. Many researchers reported that 2, 4-D is responsible for increase in 1000 grains weight (Singh *et al*., 1990). These results are in line with that of Markose *et al*. (2006) and Biradar (1999).

3.2.3. No. of grains per Pod

The data regarding number of grains per pod obtained after the harvesting of crop from the plants treated with varying level of 2, 4-D was subjected to statistical analysis and results are presented in Table 2. Number of grains per pod is one of the easily determined characters, which has a positive co-relation with the yield. The statistical analysis of the collected data for number of grains per pod showed that the effect of the application of 2, 4-D was significant in improving the number of grains per pod. The maximum number of grains (9.66) was observed in the plants in which 2, 4-D was applied @ 0.8 ppm and they produced 70.6% higher number of grains than that of control. The other three levels of 2, 4-D applied at 0.2, 0.5 and 1 ppm respectively also enhanced the number of grains but less than the 0.8 ppm and increase was 29.4%, 35.2% and 58.8% respectively as compared to control. Number of grains increased with the increased level of 2, 4-D application but up to T4 treatment which was maximum, after that it started decreasing which showed that higher doses of 2, 4-D had negative impact on grains weight. The maximum grains weight in T4 was 31.8%, 26% and 7.4% as compared to T2, T3 and T5 respectively. The minimum mean value (5.7) was noticed in control T1. This study revealed that all the treatment caused great increase in number of grains per pod as compared to control plants. Similar results were observed with 2, 4-D by Biradar (1999) and Mehta *et al*. (1989).

3.2.4. No. of grains per Plant

It was observed from the statistical analysis of the collected data for number of grains per plant showed that the effect of the application of 2, 4-D was significant in improving the number of grains per plant. The maximum number of grains (391.67) was observed in the plants in which 2, 4-D was applied @ 0.8 ppm. The other three levels of 2, 4-D applied at 0.2, 0.5 and 1 ppm respectively also enhanced the number of grains but less than the 0.8 ppm and increase was 36%, 69% and 70.7% respectively as compared to control. Number of grains increased with the increased level of 2, 4-D application but up to T4 treatment which was maximum. The maximum grains weight in T4 was 53.3%, 23.4% and 22.2% as compared to T2, T3 and T5 respectively. The minimum mean value (187.6) was noticed in control T1. The study of 2, 4-D revealed that all the treatment caused great increase in number of grains per plant as compared to control plants (Singh *et al*., 1990). Similar results were observed with 2, 4-D by Biradar (1999) and Mehta *et al*. (1989).

**Concusions**

Conclusively, findings of this experiment describe the capability of 2, 4-D to be used at lower concentrations and unlock the interest of researchers to further explore their potential as growth regulator to improve growth and productivity of mungbean and other legumes but for this further field trials are recommended. By exogenous application of plant growth regulators, positive results can be achieved provided the limitations are overcome and we use the right time of spray and required quantity of growth regulator.

**References**

Arshad, M., W.T. Frankberger. 1998. Plant growth substances in rhizosphere. Adv. Agron. 62: 46-151.

Azam, F. and A. Lodhi. 2001. Plant growth root modification in wheat and maize following addition 2, 4-dichlorophenoxy acetic acid in soil. Online J. Biol. Sci. 1 (11): 1069-1073.

Aziz, T., W. Anwar, F. Naveed and S.T. Sahi. 2010. Foliar applied 2, 4-dichlorophenoxy acetic acid improved tomato growth and yield. Soil & Environ. 29 (1): 77 – 81.

Belimov, A., V.I. Satronova, T.A. Lergeyera, T.N. Tsyganov, V.A, Matvegeva, V.V. Stepnok, V.E. Tsyganov and I.A. Tikhonovich. 2001. Characterization of plant growth promoting rhizobacteria isolated from polluted soil and containing ACC-deaminase. Can. J. Microbial. 47: 642-652.

Biradar, B.R. 1999. Investigations of seed technology aspects in chilli. Ph.D. Thesis, Univ. Agric. Sci., Dharwad, India.

Campanoni, P. and P. Nick. 2005. Auxin dependent cell division and cell elongation. 1- Naphthalene acetic acid and 2, 4-dichlorophenoxyacetic acid activate different pathways. Plant Physiol. 137: 939-948.

Chaudhary, B.R. 2004. Response of chilli (Capsicum annuum L.) to plant growth regulators. M.Sc. Thesis, Department of Horticulture, IAAS, Rampur, Chitwan, Nepal. pp. 81.

Chaudhary, B.R., M.D. Sharma, S.M. Shakya and D.M. Gautam. 2006. Effect of plant growth regulators on growth, yield and quality of Chilli. J. Inst. Agric. Anim. Sci. 27: 65-68.

Economic Survey of Pakistan. 2013. Agricultural Indicators Federal Bureau of Statistics, Statistics Division, Ministry of Economic Affairs and Statistics, Government of Pakistan.

Farah, H., A. Iqbal and S.K.H. Mohd. 2004. Indol acetic acid production by indigenous isolates of Azotobacter and fluorescent Pseudomonas in presence and absence of tryptophan. Turk J. Boil. 20: 29-34.

Frankenberger, W.T. and M. Arshad. 1991. Yield response of watermelon and muskmelon to L-tryptophan applied to soil. Hort. Sci. 26(1): 35-37.

Gelmesa, D., B. Abebie and L. Desalegn. 2012. Regulation of tomato fruit setting and earliness by gibberellic acid and 2, 4-dichlorophenoxy acetic acid application. Afr. J. Biotechnol. 11 (51): 11200-11206.

Hobbie, L.J. 1998. Auxin: molecular genetic approaches in Arabidopsis. Plant Physiol. Biochem. 36: 91-102.

Hontzeas, N., S.S. Saleh and B.R. Glick. 2004. Changes in gene expression in canola roots by ACC-deaminase containing plant growth promoting bacteria. J. Molec. Plant Microb. Interact. 17: 865-871.

 

Kannan, K., M. Jawaharlal and M. Prabhu. 2009. Effect of plant growth regulators on growth and yield parameters of paprika cv.KtPl-19. Agric. Sci. Digest. 29 (3): 157-162.

Kevin, V.J. 2003. Plant growth promoting rhizobacteria as biofertilizer. Plant and soil. 255: 571-585.

Khalid, A., M. Arshad and Z.A. Zahir. 2004. Screening plant growth promoting rhizobacteria for improving growth and yield of wheat. J. App. Microbial., 96: 473-480.

Khalid, A., M. Arshad and Z.A. Zahir. 2006. Phytohormones: microbial production and applications. In: Biological approaches to sustainable soil system. (eds): N. Uphoff, A.S. Ball, E. Fernades, H. Herren, O. Hussain, M.Laing, C. Palim, J. Pretty, P. Sanchez, N. Sanginga and J. Thesis. Taylor & Francis/CRC, Boca Raton, Florida: 207-220.

Leinhos, V., 1994. Effect of pH and glucose on auxin production by phosphate solubilizing rhizobacteria in vitro. J. Micro. Res. 194: 135-138.

Markose, B.L., S. Rajan and J.R. Gopalakrishnan. 2006. Influence of bioregulators on productivity in tomato. p. 103. *In*: Proceedings of National Seminar on AJSH. 21-22 March. 2006. Annamalai Univ. Tamil Nadu.

Mehta, A.K., R.P Singh and G. Lal. 1989. Effect of concentration and methods of application of 2, 4-D phenoxy acetic acid on yield, fruit quality and seed quality of tomato. Veg. Sci. 16 (1): 1-8.

Perigio, B., Jr. Francisco, S. Akao, and M. Kokubun. 1991. The Timing of Exogenous 2, 4 Dichlorophenoxyacetate (2, 4-D) Application Affects Nodulation of Soybeans, *Glycine max* (L.) Merr. Soil Sci. Plant Nutr. 37 (4), 707-714.

Poudel, P. 2006. Effect of plant growth regulators on yield and yield component of sweet pepper during spring – summer at Kalyanpur, Chitwan. M. Sc. Thesis, Department of Horticulture, IAAS, Rampur, Chitwan, Nepal. pp 57.

Rajamani, K., J.S. Rajan and D.V. Ragavathatham. 1990. Effect of triacontonil, 2, 4-D and boron on the yield of certain chilli (Capsicum annum L.) cultivars. South Ind. Hortic. 38 (5) : 253-257.

Rajesh, P., 2005. Effect of plant growth promoting rhizobacteria on canola and lentil plants. EDT Project.

Ray, S. and M.A. Choudhuri, 1981. Effects of Plant Growth Regulators on Grain-filling and Yield of Rice. Annals of Botany, 47: 755-758.

Resmi, R., and T.R. Gopalakrishnan. 2004. Effect of plant growth regulators on the performance of yard long bean (*Vigna unguiculata var. sesquipedalis* (L.) Verdcourt). Journal of Tropical Agriculture 42 (1-2): 55-57.

Ricard, D., Lardizabal and P.G. Thompson. 1990. Growth Regulators Combined with Grafting Increase Flower Number and Seed Production in Sweet Potato. Hort. Sci. 25(1):79-81

Rossi, W.A., Grappelli and W. Pietrosanti. 1984. Phytohormones in soil after atrazine application. J. Folia. Microbial. 29: 325-329.

Rossi, W.A., Grappelli and W. Pietrosanti. 1984. Phytohormones in soil after atrazine application. J. Folia. Microbial. 29: 325-329.

Singh, D.K., G. Lal and R.P Singh. 1990. Effect of synthetic auxins on the performance of chilli. Cultivars under tarai conditions of UP during winter season. Prog. Hortic. 22: 191-197.

Spaenpen, S., J. Vanderleyden and R. Remans. 2007. Indol-3-acetic acid in microbial and microorganism plant signaling. FEMS Microbial: 1-24.

Tchan, Y.T., A.M.M. Zeman and I.R. Kennedy. 1991. Nitrogen fixation in para-nodules of wheat roots by introduced free-living diazotrophs. Plant and Soil 137: 43-47.

Teale, W.D., I.A. Paponov and K. Palme. 2006. Auxin in action: signaling, transport and control of plant growth and development. Nature Rev. Mol. Cell Biol. 7: 847-859.

Tuan, N.M., and Y.C. Ruey. 2013. Response of Wax Apple Cultivars by Applied GA3 and 2, 4-D on Fruit Growth and Fruit Quality. World Academy of Science, Engineering and Technology: 73.

Uddain, J., K.M. Akhter Hossain, M.G. Mostafa and M.J. Rahman. 2009. Effect of Different Plant Growth Regulators on Growth and Yield of Tomato. International Journal of Sustainable Agriculture. 1 (3): 58-63.

Zahir, Z.A., H.M. Yaseen, M. Naveed, M.A. Anjum, M. Khalid. 2010. L- tryoptophan application enhance the effectiveness of rhizobium inoculation for improving growth and yield of mungbean. Pak. J. Bot. 42 (3): 1771-1780.