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Effect of Application of Calcium Carbide on Growth of Cotton Crop

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Abstract: A pot experiment was conducted to evaluate the effect of calcium carbide (ethylene) on growth of cotton (*Gossypium hirsutum* L.), in wire house Department of Soil Science, University of Agriculture, Faisalabad in 2001-2002. BH-36 cotton variety was sown and calcium carbide (CaC_2) was applied to the soil as ethylene producing compound. Normal soil, @ 12 kg pot^{-1}, was used and recommended dose (120-100-60 kg ha^{-1}) of N, P and K was applied. However, half dose of N and full dose of P and K was applied at sowing while remaining half dose of N was applied after two weeks of germination. Calcium carbide was applied @ 60 kg ha^{-1} at two growth stages, i.e., before flowering and after flowering which correspond to 18 to 60 days after sowing. A factorial, completely randomized design, was followed with nine treatments and three repeats. Data regarding plant height cm, number of branches plant^{-1} ,shoot fresh weight g plant^{-1}, shoot oven dry weight g plant^{-1}, root weight g plant^{-1} , number of bolls plant^{-1} was recorded and statistical procedures were followed to analyze the data. All the growth parameters were influenced significantly. Best time of application of calcium carbide was after two weeks of germination. However, in certain parameters i.e. plant height ,number of branches, shoot fresh weight, root weight and no. of bolls were statistically at par in the treatment where CaC_2 was applied after 8 weeks of germination.

Key words: Cotton, calcium carbide, growth

Introduction

Cotton is one of the main cash crops of Pakistan. It has played a significant role in industrial development and employment generation. It is known as back bone of Pakistan's economy. Its impact on the economic development of the country is well established and it is rightly known as the silver fibre of Pakistan. Presently it is being grown on an area of 2.9 million hectares with a total production of 10.7 million bales. Its contribution to agriculture is 11.5% and contribution to GDP is 2.8% (GOP, 2001-02).

A wide range of factors control the growth and yield of cotton one of these is plant growth regulators. The use of plant growth regulators (PGRs) in the field of Agriculture has been commercialized in some advanced countries like Europe, USA and Japan. These substances do not become part of living cell but amazingly affect the plant growth (Nickell, 1982). The microbial production of phytohormones is well documented in literature (Barea *et al.,* 1976). It can be enhanced by application of certain precursors, which provide a new opportunity to increase the crop production (Arshad and Frankenberger, 1988.

Ethylene (C_2H_4) is one of the phytohormones that can affect several aspects of plant growth and development (Primrose, 1979). Ethylene is produced in all plant organs including roots, stems, leaves, buds, tubers, flowers and seeds (Chadwick *et al.,* 1986). In the plant growth regulator section of the All-Russian Scientific Research Institute of Agricultural Biotechnology (ARSRIAB) jointly with the St. Petersburg Institute of Basic Chemical Industry a new ethylene producing preparation, Ratprol, has been developed, which is a preparative form of calcium carbide. It is introduced to the soil, where under the influence of soil moisture the calcium carbide decomposes with the formation of calcium hydroxide and acetylene. In the presence of an enzyme (Nitrogenase) this acetylene is then reduced by soil microorganisms to ethylene, which enters the plants through the roots. Calcium carbide as an ethylene precursor is now well established with calcium hydroxide and acetylene as intermediates (Muromtsev *et al.,* 1988). A diverse group of microbiota, including both pathogens and non pathogens are also very active in producing C_2H_4 (Primrose, 1979). Addition of calcium carbide and Retprol stimulate the biosynthesis of C_2H_4 in soil (Bibik *et al.,* 1995).

Physiological effects of substrate (calcium carbide) derived, microbially produced C_2H_4 in plant growth have been reported by few workers. Muromtsev *et al.* (1988) reported that calcium carbide when applied @ 30 and 60 kg ha^{-1} promoted the cluster number, the mean fruit weight and the portion of ripe fruits 20-25, 20 and 50% respectively, as compared to the control. Muromtsev *et al.* (1993) investigations revealed that the application of calcium carbide resulted in a significant increase of the ethylene level in the air of various soil types. Bibik *et al.* (1995) reported the influence of calcium carbide, increased tuber formation, potato yield, tuber preservation and also disease resistance.

The effect of calcium carbide and Retprol was studied on potato, this study showed significant increase in seedling appearance, number of total tubers and the yield. Potato tubers shelf life was enhanced if grown under the influence of Retprol and calcium carbide. The ethylene enhanced the female sex ratio in the stands of dioecious hemp, there by an increase in seed yield (Muromtsev *et al.*, 1993). As ethylene is a gas, its application in the soil for plant benefit is a complex practice. Synthetic substances, ethylene producers which break down in plants with the liberation of elthylene are, therefore, used in agricultural practices (Muromtsev *et al.,* 1988). Existing ethylene producers are relatively expensive the search for inexpensive and readily available ethylene producers is, therefore, an important task of agricultural biotechnology. Considering the above stated effect of CaC_2 (ethylene), the present study was planned to evaluate its effect on growth of cotton (BH-36).

Materials and Methods

A pot experiment was conducted in the wire-house, Department of Soil Science, University of Agriculture, Faisalabad, to evaluate the effect of ethylene on growth of BH-36 Variety of cotton. Calcium carbide was applied as an ethylene precursor during the year 2001. Bulk surface soil (0-15 cm) was collected from the field, air dried, ground and passed through 2 mm sieve. A composite sample was taken and analysed for physical and chemical characteristics (Table 1).

Each pot was filled with processed soil @ 12 kg per pot. At field capacity, recommended doses of N,P & K (120-100-60 kg ha^{-1}) and half dose (60-50-30 kg ha^{-1}), using urea, SSP and SOP as sources of N, P and K respectively, were applied. Half dose of nitrogen was applied at sowing and remaining ½ with 1st irrigation. Four seeds of cotton (BH-36) were sown per pot at field capacity level of the pots. Thinning was done and two plants per pot were maintained. The first dose of calcium carbide was applied to the plants at first irrigation, which corresponds to 2 weeks and second dose after 8 weeks of germination @ 60 kg ha^{-1}. The recommended dose of CaC_2 (0.3 g) was filled in capsules and capsules were placed 3 cm deep and 5 cm wide from the main root, after 1st irrigation, when the pots were at field capacity. The experiment was laid out in complete randomized design with nine treatments and three replications. Each repeat had two plants. Canal water was used for irrigation. Data regarding pre and post harvest growth and yield characteristics was recorded.

Soil analysis: The following determinations on soil were made according to the methods described by the U.S. Salinity Laboratory Staff (1954) unless otherwise mentioned.

Mechanical analysis: To 40g of soil sample, 40 mL 2% sodium hexametaphosphate solution was added and left over night. The soil was stirred with a mechanical stirrer and reading was recorded with Bouyoucos hydrometer (Moodie *et al.*, 1959). The triangle used was based on the International System of Textural Classification.

pH of the saturated soil paste (pHs): pH_s was recorded by pH meter (Toa, HM-12P) with glass electrodes using buffers of pH 4.0 and 9.2 as standards (Method 21a).

Electrical conductivity of the saturation extract (EC_e): EC_e of extract was measured by using digital Jenway, Model 4070 conductivity meter (Method 4b; p. 89).

Saturation percentage: Saturation percentage was calculated by using the formula: (Method 27a; p107)

$$SP = \frac{W_2 - W_1}{W_2} \times 100$$

Where:

W1 = Weight of saturated soil paste

W2 = Weight of saturated soil paste after oven drying (Method 27a).

Soluble Ca^{++}+ Mg^{++}: Soluble calcium plus magnesium were determined by titration of the saturated soil extract with 0.01 N EDTA solution using eriochrome black T as indicator (Method 7; p 94).

Cation exchange capacity (CEC): CEC was determined by Croning 410 flame photometer.

Organic matter: Organic matter was determined by titrating a mixture of potassium dichromate , concentrated sulphuric acid ,distilled water and 0.5 N ferrous sulphate against 0.1N potassium permagnate solution to pink end point.

Total nitrogen: Nitrogen was determined by Gunning and Hibbard's sulphuric acid digestion and distillation of ammonia into 4% boric acid by Macro Kjeldahl's apparatus (Jackson, 1962).

Available phosphorus: Available phosphorus was calculated by Olsen's extraction method. Readings were recorded, using 880 nm wavelengths and with the help of standard curve.

Extractable potassium: The extraction was done by ammonium acetate (1 N of pH 7.0) and potassium was determined by Method 18.
Statistical procedures were applied to analyze the data (Steel and Torrie, 1980) using CRD (factorial) and means were compared by Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion
Calcium carbide upon decomposition and hydrolysis in the rhizosphere is converted into $Ca(OH)_2$ and acetylene gas. Acetylene decomposes into ethylene by microbes in the presence of an enzyme (nitrogenase). Ethylene is a plants growth promoting hormone whose positive effects on growth, plant development and plant physiological processes are well established and documented in the literature. Keeping all these facts in view data on the influence of CaC_2 with and without fertilizers is discussed in the following pages.

Height of cotton plant (cm): Mean height was significantly maximum in the treatment where CaC_2 was applied compared to control. Plant height in treatments of two and eight weeks of germination was statistically at par (Table 2).
Substantial increase in plant height was observed with fertilizer application. Fertilizer application had significant effect on plant height. Maximum average height was observed where N,P & K fertilizer was applied @ 120-100-60 kg ha^{-1}, followed by the treatment where N,P & K fertilizers were applied @ 60-50-30 kg h^{-1} and control. It is quite evident from the data presented in Table 2 that full dose (120-100-60 kg ha^{-1}) and half dose (60-50-30 kg ha^{-1}) of N,P & K fertilizers produced similar results. Plant height increased with availability of nutrients as is clear from control. Dahnous *et al* . (1982), Muromtsev *et al.* (1988), Arshad *et al.* (1994), Bibik *et al.* (1995) and Sharma and Yadav (1996), reported similar results in different crops. Time of application of CaC_2 and fertilizers interation revealed quite variation in plant height of cotton with the application of CaC_2 and fertilizer over control. Application of CaC_2 alone increased the height compared to the treatment where CaC_2 was not applied. Increase in height was also observed with application of CaC_2 and both of fertilizer doses i.e. half and full doses of fertilizers.

Number of branches per plant: Each entry of data in rows and columns is mean of three repeats. Maximum average number of branches were observed where CaC_2 was applied after 2 weeks of germination. It was followed by the treatments where CaC_2 was applied after 8 weeks of germination and control respectively. Average number of branches were statistically similar in control and treatment where CaC_2 was applied after 8 weeks of germination.

Table 1: Physical and chemical characteristics of soil

Characteristic	Value	Unit
Sand	72.50	%
Silt	11.59	%
Clay	12.91	%
Textural class	Sandy loam	
Saturation percentage	35	-
pHs	7.7	-
EC_e	1.61	ds m^{-1}
Soluble Ca^{++}+ Mg^{++}	8.91	me L^{-1}
CEC	4.75	(mol Kg^{-1})
Total Nitrogen	0.05	%
Available phosphorous	8.35	Ppm
Extractable K^+	125	Ppm
Organic matter	0.73	%

Table 2: Effect of time of application of CaC_2 with and without N,P & K fertilizer on height cm of cotton plant

Treatment $N\text{-}P_2O_5\text{-}K_2O$ kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1}			
	Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0- 0- 0	30.00	41.50	37.50	36.30b
60 - 50-30	52.32	62.30	60.80	58.50a
120-100-60	55.82	62.30	60.00	59.40a
Mean	46.03b	55.36a	52.76a	

Table 3: Effect of time of application of CaC_2 with and without N,P & K fertilizer on number of branches plant[-1] of cotton at maturity.

Treatment $N\text{-}P_2O_5\text{-}K_2O$ kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1}			
	Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0 -0-0	1.00	2.00	1.66	1.55b
60 -50-30	3.00	5.33	4.00	4.44a
120-100-60	3.33	4.66	4.33	4.11a
Mean	2.77b	4.00a	3.33ab	

Table 4: Effect of time of application of CaC_2 with and without N,P & K fertilizer on shoot fresh weight of cotton (g $plant^{-1}$)

Treatment $N\text{-}P_2O_5\text{-}K_2O$ kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1}			
	Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0-0-0	37.44	56.09	44.48	46.01b
60-50-30	78.14	88.71	89.79	84.89a
120-100-60	72.17	81.29	75.79	76.39a
Mean	62.58b	75.37a	69.33ab	

Table 5: Effect of time of application of CaC_2 with and without N,P & K fertilizer on shoot oven dry weight (g $plant^{-1}$) of cotton

Treatment $N\text{-}P_2O_5\text{-}K_2O$ kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1}			
	Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0-0-0	11.30cd	14.82ab	10.66cd	12.26
60-50-30	9.59d	16.93a	10.42cd	12.31
120-100-60	11.68cd	15.03a	12.57bc	13.09
Mean	10.86b	15.60a	11.22b	

Table 6: Effect of time of application of CaC_2 with and without N,P & K fertilizer on root weight (g pot^{-1}) of cotton

Treatment N-P_2O_5-K_2O kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1} Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0 — 0 — 0	2.69	5.66	3.73	4.03b
60 – 50–30	4.33	5.41	5.08	4.94ab
120-100-60	5.20	6.14	5.57	5.63a
Mean	4.07b	5.74a	4.79ab	

Table 7: Effect of time of application of CaC_2 with and without N,P & K fertilizer on number of bolls $plant^{-1}$ of cotton

Treatment N-P_2O_5-K_2O kg ha^{-1}	Time of application of CaC_2 @ 60 kg ha^{-1} Control	After 2 weeks of germination	After 8 weeks of germination	Mean
0 — 0 — 0	6.00	11.00	12.00	9.66b
60 – 50–30	10.00	15.00	16.66	13.89a
120-100-60	9.00	21.00	22.33	17.67a
Mean	8.33b	15.89a	17.00a	

Results clearly show (Table 3) that application of CaC_2 @ 60 kg ha^{-1} significantly increased number of branches in cotton and best time for its application is after 2 weeks of germination.

Number of branches increased by the application of N, P and K fertilizers when compared to control. Maximum number of branches were observed where N,P & K fertilizer was applied @ 60-50-30 kg ha^{-1}. Number of branches of cotton in the treatments where full dose of recommended N,P & K fertilizers were applied (120-100-60 kg ha^{-1}), were also comparable to the treatment where half dose of fertilizer was applied (60-50-30 kg ha^{-1}). Minimum number of branches were observed in control where no N, P and K fertilizers were applied. Increase in number of branches of cotton would be induced by the application of fertilizers. However further increase in number of branches over was due to the production of ethylene in rhizosphere, which stimulates the growth. These results are in line with the findings of Muromtsev *et al*. (1993) Arshad *et al*. (1994), Sharma and Yadav (1996) and Arshad and Frankenberger (1998) reported similar results.

Interaction between time of application of CaC_2 and different rates of N, P & K fertilizers is evident that CaC_2 and fertilizer in combined had effect on number of branches per plant compared to control. This effect is particularly true when data in control and in the treatment where CaC_2 was applied after 2 weeks of germination. Maximum number of branches of cotton were observed in the treatment where N,P & K fertilizer @ 60-50-30 kg ha^{-1} and CaC_2 @ 60 kg ha^{-1} were applied. There results are in lime with the findings of Sharma and Yadav (1996).

Shoot fresh weight (g $plant^{-1}$): Shoot fresh weight was significantly maximum with application of CaC_2 when compared with control (Table 4). Among CaC_2 treatment, shoot fresh weight was maximum where CaC_2 was applied after 2 weeks of germination than where CaC_2 was applied after 8 weeks of germination.

Application of different levels of N,P & K fertilizers also influenced the shoot fresh weight of cotton. Maximum shoot fresh weight was observed where N,P and K fertilizer was applied @ 60-50-30 kg ha^{-1} and it was statistically at par where N,P & K fertilizer was applied @ 120-100-60 Kg ha^{-1}. Minimum shoot fresh weight was observed in control, where no fertilizer was applied. It is obvious from the data presented in Table 4 that, application of fertilizer increased shoot fresh weight significantly over control. Overall,data reflect that half dose of fertilizer (60-50-30 kg ha^{-1}) was more effective to increase the shoot fresh weight than full dose of fertilizer (120-100-60 kg ha^{-1}).

Time of application of CaC_2 and fertilizer interaction increased the shoot fresh weight non-significantly compared to control. Increase in shoot fresh weight with fertilizer and CaC_2 alone and in combination reflected response of cotton. Application of CaC_2 @ 60 kg ha^{-1} along with 60-50-30 kg ha^{-1} of N,P & K fertilizer produced maximum shoot fresh weight, while it was minimum in control. The results obtain on shoot fresh weight are in line with the findings of Dahnous *et al*. (1982) , Sharma and Yadav (1996) and Arshad and Frankenberger (2002) have already reported the marked influence of ethylene on plant growth. All of them observed significant increase in biomass of different crops with the application of CaC_2.

Shoot oven dry weight (g $plant^{-1}$): Maximum shoot oven dry weight was observed where CaC_2 was applied after 2 weeks of germination @ 60 kg ha^{-1}(Table 5). It was followed by the treatments where CaC_2 was applied after 8 weeks of germination and control, respectively. Results clearly indicate that mean oven dry shoot weight increased with the application of CaC_2 @ 60 kg ha^{-1}.

Fertilizer application had least effect on shoot oven dry weight. All fertilizer treatments means differed non-significantly. It means that all the fertilizer treatments including control produced more or less similar shoot oven dry weight.

Interaction between time of application of CaC_2 and fertilizer elucidated the combined influence of CaC_2 and fertilizers on shoot weight compared to control. Increase in oven dry weight of shoot with fertilizer and CaC_2 alone and in combination (Table 5) depicted response of cotton. Application of CaC_2 along with 120-100-60 kg ha^{-1} of N,P and K fertilizer produced maximum shoot oven dry weight. These results are in complete compliance with the findings of Muromtsev *et al*. (1988), Muromtsev *et al*. (1991), Muromtsev *et al*. (1993), Sharma and Yadav (1996) and Arshad and Frankenberger (2002). All of them reported similar results.

Root weight (g plant^{-1}): Maximum root weight was observed where CaC_2 was applied after 2 weeks of germination (Table 6). Treatments where CaC_2 was applied after 8 weeks of germination and control where CaC_2 was not applied followed it. Results clearly show that root weight significantly increased with the application of CaC_2 @ 60 kg ha^{-1}. It may be due to CaC_2 that produced ethylene in rhizosphere which is absorbed by plant and stimulated initial root growth and thus more carbohydrates translocated towards root and caused increase in root weight. Arshad and Frankenberger (2002) discussed the effects of ethylene producing compounds like CaC_2 on plant growth and development in detail in their book.

Application of different levels of N, P & K fertilizer significantly influenced the fresh root weight of cotton. There was a substantial increase in root weight with increase in fertilizer rates. Maximum root weight was observed where N,P & K fertilizer were applied @ 120-100-60 Kgha^{-1} while, it was minimum in control where no fertilizer was applied. It is obvious from data presented in Table 6 that application of fertilizer @ 120-100-60 kg ha^{-1} increased fresh root weight significantly over control.

Interaction between time of application of CaC_2 at different growth stages and different rates of N,P & K fertilizers application elucidates the influence of CaC_2 and fertilizers when compared to control. Although, the interaction is non significant, increase in root weight was consistent, both with time of CaC_2 and fertilizer application however pronounced increase was observed by application of fertilizer @ 120-100-60 kg ha^{-1} and CaC_2 @ 60 kg ha^{-1} after two weeks of germination. This means that application of CaC_2 along with 120-100-60 kg ha^{-1} of N, P & K fertilizer produced maximum root weight while it was minimum in control. Over all, results indicate positive influence of CaC_2 alone and in combination with N,P & K fertilizers.However, maximum influence was observed when CaC_2 was applied in combination with fertilizers @ 120-100-60 kg ha^{-1}.

The results are in complete compliance with the findings of Muromtsev *et al.* (1988), Bibik *et al.* (1995) Sharma and Yadav (1996) and Arshad and Frankenberger (2002) . All of them observed significant increase in biomass of different crops with the application of CaC_2.

Number of bolls plant^{-1}: Maximum average number of bolls (average of three repeats) were observed where CaC_2 was applied after 8 weeks of germination (Table 7). It was followed by treatment where CaC_2 was applied after 2 weeks of germination and control. Average number of bolls per plant was statistically similar in both the treatments where CaC_2 was applied. Results clearly show that application of CaC_2 regardless the time of application increased the production of bolls however; this increase was relatively more with CaC_2 application just before flower initiation.

Number of bolls per plant was also affected by the application of fertilizer in different doses. Maximum number of bolls was observed where N,P & K fertilizers were applied @ 120-100-60 kg ha^{-1}. Means of the treatments show that mean number of bolls per plant with half dose of fertilizer (60-50-30 kg ha^{-1}) and full dose (120-100-60 kg ha^{-1}) of fertilizer were comparable and statistically similar. Minimum number of bolls was observed in control. Increase in number of bolls per plant would be induced by the application of fertilizers. However further increase in number of bolls was due to the production of ethylene in rhizosphers which stimulates flower bud initiation and thus increased the boll formation. These results are in line with the findings of Arshad *et al.* (1994), Sharma and Yadav (1996), Arshad and Frankenberger (1998) and Arshad and Frankenberger (2002).

Interaction between CaC_2 and fertilizers revealed pronounced influence on number of bolls per plant even that it was non-significant. Least differences in the values of data of time of application of CaC_2 might have marked the influence interaction which otherwise may be significant as is obvious from wider differences among values of data in Table 7. It is evident from the data that number of bolls increased with the application of CaC_2 with fertilizer. Maximum number of bolls were observed in the treatments where N, P & K fertilizers @ 120-100-60 kg ha^{-1} and CaC_2 @ 60 kg ha^{-1} were applied. Sharma and Yadav (1996) reported that application of CaC_2 @ 80 ppm with 60 ppm of nitrogen showed results comparable and equal to 120 ppm of nitrogen alone

References

Arshad, M., M. Javed and A. Hussain, 1994. Response of Soybean (*Glycin max*) to soil applied precursors of phytohormones. PGRSA Quarterly, 22: 109-115.

Arshad, M. and W.T. Frankenberger Jr., 1988. Influence of ethylene produced by soil microorganisms on etiolated pea seedlings. Appl. Enrion. Microbiol., 54: 2728-2732.

Arshad, M. and W.T. Frankenberger Jr., 1998. Plant growth regulating substances in the rhizosphere: Microbial production and functions, Adv. Agron., 62: 45-151.

Arshad, M. and W.T. Frankenberger Jr., 2002. Ethylene: Agricultural sources and applications. Kuiwer Academey plenum publ., New York, pp: 342

Barea, J., M. E. Navar and E. Montoya, 1976. Production of Plant growth regulators by rhizophere, phosphoate solubilizing bacteria. J. Appl. Bacterioil., 40: 129-134.

Bibik, N.D.S., V. Lenova, E.V. Druchek and G.S. Muromtsev, 1995. Effectiveness of a soil-acting ethylene producer in obtaining sanitized seed potato. Russian Agril. Sci., 5: 14-15.

Chadwick, A.V., L. P. Zyman and J. Arditti, 1986. Sites of thylene evaluation in Orchid flowers. South Western Adve,. Col., Texas USA. Lindleyana, 1: 164-168.

Dahnous, K., G.T. Vigue, A.G. Law, C.F. Konzak and D.G. Miller, 1982. Height yield responses of selected wheat, barely and triticale cultivars to ethephon. Agron. J., 74: 580-582.

Duncan, D.B., 1955. Multiple Range and Multiple F. Test. Biometrics, 11: 1-42.

GOP., 2001-2002. Economic Survey. Govt. of Pakistan, finance Div. Econo. Adv. Wing. Islamabad, Pakistan, pp: 9.

Jackson, M.I., 1962. Chemical composition of soil. In F.E.Bean (ed). Chemistry of soil. Van Nostrand Reinheld Co., New York, pp: 71-144.

Moodie, C., D.H.W. Smith and R.A. McCreery, 1959. Laboratory Manual of Soil Fertility. Dept. Agron. State College Washington Pullman, Washington. U.S. App., pp: 1-175.

Muromtsev, G.S., N.P. Krasinskaya, S.V. Letunova and I.G. Baresh, 1991. Application of an ethylene producing preparation with soil activity on citrus crops. Doklady Vsesoyuznol Ordena Lenia-I-Ordena Trudvogo Krasnogo Zrameni Akademii Sel'skohozaistvennykh Nauk-im-V.K.leina, 5: 9-11.

Muromtsev, G.S., S.V. Leutnova, I.G. Beresh and S.A. Alekseeva, 1988. Soil ethylene as a plant growth regulator and ways to intensify its formation in soil. Research institute of Biotechnology, Moscow, 5: 731-738.

Muromtsev, G.S., S.V. Leutnova, L.N. Rentovich, Zh.L., Timpnova, I. Yu Gorbatenko, O.A. Shapoval, N.D. Bibik, G.S. Stepanov and Ye.V. Druchek, 1993. Retprol New ethylene releasing preparation of soil activity. Russian Agril. Sci., 7: 19-26.

Nickell, L.G., 1982. Plant growth regulators: Agriculture Uses. Springer Verlag New York, pp:173. Pencillium digitatum. J. Agric. Res., 60: 269-277.

Primrose, S.B., 1979. A review, ethylene and agriculture. The role of microbes. J. Appl. Bacteriol., 46: 1-25.

Sharma, J.P. and B.R. Yadav, 1996. Increasing urea efficiency in rice-wheat cropping sequence through addition of some calcium salts and potassic fertilzer. Current-Agric., 20: 73-76.

Steel, R.G.D. and J. Hl Torrie, 1980. principal and procedures of Statistics. McGraw Hill Book Co. Inc. new York. U.S.A.

U.S. Salinity Laboratory Staff, 1954. Diagnosis and Improvement of Saline and Alkaline Sils. USDA Handbook No. 60. Washington. D.C., U.S.A.