

## Field Bio-Efficacy and Phyto-Toxicity of Vitormone (*Azotobacter chroococcum* L.) on Growth and Yield Contributing Characters in Chilli (*Capsicum annum* L.)

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### ABSTRACT

Chilli (*Capsicum annum* L.) is one of the important spice and vegetable crop grown in India and World. Hence, the present trial was conducted during 2014-15 at Zonal Agricultural Research Station, Jhabua (RVSKVV – Gwalior) – 457661 Madhya Pradesh, with a view to assess the bio-efficacy of Vitormone (*Azotobacter chroococcum*) on chilli hybrid. Vitormone study was undertaken at 0.5, 1.0 and 2.0 ml/L along with 100% NPK (RDF) and 75% N and 100% PK at KVK Jhabua. Results obtained revealed that spraying of Vitormone @ 2.0 ml/L along with recommended dose of fertilizer (RDF) at 35, 55 and 75 days after transplanting significantly increase in plant height (19.77%), number of branches/plant (80.0%), fruit length (81.52%), number of fruits/plant (51.12%) and yield by 43.24% over control and by 4.44% more over RDF. Likewise, spraying of Vitormone @ 2.0 ml/L did not show any phytotoxic effect on chilli crop.

**Keywords-** Chilli, *Capsicum annum*, Vitormone, *Azotobacter chroococcum*, Bio-fertilizer, Phytotoxicity, Chilli yield.

### I. INTRODUCTION

Biofertilizer consist mainly of beneficial micro-organisms that can release nutrients from raw materials and plant residues in the soil and make them available commercially where strains are used as biological fertilizers. They become recently, positively alternatives to chemical fertilizers because they help bring down the costs of chemical fertilizers especially N and P and improve soil fertility by maintaining the physical properties of the soil. They may help in improving crop productivity and quality by increasing the biological nitrogen fixation, the availability and uptake of nutrients and stimulating the natural hormones. They are safe for humans, animals and environment and using them is occupied with reducing the pollution occurring in our environment.

Continuous use of chemical fertilization leads to the deterioration of soil characteristics and fertility and

might lead to the accumulation of heavy metals in plant tissues affecting the fruit nutritional value and edibility Shimbo et. al. (2001). Biological fertilization is based on the use of natural inputs including fertilizers, decaying remains of organic matter, domestic sewage, animal manure, and micro-organisms such as fungi and bacteria (Chirinos et. al. 2006). Applications of bio-fertilizers containing beneficial micro-organisms instead of synthetic chemicals are known to improve plant growth through the supply of plant nutrients and may help to sustain environmental health and soil productivity. (O'connell, 1992). They are known to improve fixation of nutrients in the rhizosphere, produce growth stimulants for plants, improve soil stability, provide biological control, biodegrade substances, recycle nutrients, promote mycorrhiza symbiosis and develop bio-remediation process in soils contaminated with toxic and recalcitrant substances (Revera-cruzet. al. 2008). Additionally, the use of bio-fertilizers can improve productivity per unit area in a relatively short time, consume smaller amounts of energy, increase soil fertility and promote antagonism and biological control of phytopathogenic organisms (Corpoica, 2007). The great availability and release of N, P and K due to application of bio-fertilizers were reported by Ahmed and El-Daweverly (1992) on olives, Singh and Sharma (1993) on sweet oranges, Abd-Rabou (2006) on avocados and Mangoes and Al-Ashkar et. al. (2007) on bananas. Bio-fertilizers are the most important for plant production and soil as they play an important role in improving fruit quality and yield in grape-vines (Aklet. al. 1997). Also, El-Nagger (2004) showed that mycorrhiza and phosphobacterium, *Rhizobium* and *Azotobacter* were favorable in improving nutritional status of trees, yield, physical and chemical properties of grapevines. Aseriet. al. (2008) found that the use of bio-fertilizers gave a significant improvement of fruits of pomegranate in India as well as enhancing the rhizosphere microbial activity and concentrations of various nutrients.

Plant need nutrients, particularly nitrates and nitrites. As these nitrogen compounds are used by plants, a variety of micro-organisms, commonly known as nitrogen fixers are involved in a process of regeneration.

However, this process is insufficient to provide the nutrients required to maintain the high plant yield demanded by a decrease in available land due to population growth. Hence, the full potential for biological nitrogen fixation for crop production must be explored.

Much work has been done on symbiotic and free living soil bacteria with the object of exploiting them as bio-fertilizers (Ram et. al. 1995, Malik et. al. 1992, Veeraswamy et. al. 1992) and most of this has been described by Subba Rao (1986) and Saxena and Tilak (1994). Exploitation of nitrogen fixing bacteria on the phyllophane began with the work of Ruinen (1956). Since then a number of scientists e.g. Patil and Chandra (1981), Nandi et. al. (1983), Sen et. al. (1985) and Sen (1988) have concentrated on the aerial parts of plants for nitrogen supply through bio-fertilizers (Kanitkar and Kanitkar 2004, Inamdar et. al. (2000). The foliar application of biofertilizers has many advantages : (i) the nitrogen is being fixed close to its place of assimilation, (ii) the nitrogen-fixing bacteria on the phyllophane can act as antagonists to many plant pathogens if the right strains are used, (iii) there is enough food material for NFBs on the phyllophane in the form of leaf leachates and degrading cuticle which is better suited to symbiotic nitrogen-fixing bacteria (Sen, 1988) and (iv) the NFBs face less competition by other microflora on the phyllophane than in soil.

*Azotobacter* species are generally known for the use of non-symbiotic nitrogen fixing bacteria which are beneficial to various crops due to its properties like nitrogen fixation and secretion growth promoting substances, vitamins and phosphate solubilization. *Azotobacter chroococcum* is an asymbiotic nitrogen fixing bacteria and usually applied to the soils. However, Vitormone contains *A.chroococcum* a strain that has been isolated from foliage. Its ability to multiply and survive and provide plant growth promoting effects on foliage has been tested. It utilizes leaf exudates as food to fix atmospheric N<sub>2</sub> as well as secret PGPS. *Azotobacter chroococcum* are free living which depends on an adequate supply of reduced carbon compounds such as sugars for their energy source (Kennedy and Tehan, 1992). Previous study has shown that application of biofertilizer supplement the chemical fertilizers and restore soil fertility. Yield of cotton (Patil and Patil, 1984), wheat (Soliman et. al., 1995) rice (Yanni &

Fattah), Cucumber (Kanitkar et. al. 2013), soybean (Raut et. al. 2014), French bean (Raut et. al. 2014b), tomato (Raut et. al. 2016), Grapes (Ramteke et. al. 2016) increased with the application of *Azotobacter*. Similarly, bio-fertilizers are microbial inoculants for increasing the growth and acts as a biocatalyst in providing valuable nutrients to the plants (Ruinen, 1979 and Kanitkar 2006). Therefore, the present investigation was undertaken to see the performance of Vitormone (*Azotobacter chroococcum*) liquid bio-fertilizer on crop growth components and yield of chilli.

## II. MATERIAL AND METHODS

A field experiment was conducted during Kharif-2014 season at Krishi Vigyan Kendra, Jhabua, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Madhya Pradesh. It is situated in Western part of Madhya Pradesh in between latitude 21.20 and 23.40 north and between longitude 74.30 and 75.16 east. The mean altitude ranges from 450 to 750 meter above mean sea level. The soils of the zone are light red and black with shallow to medium depth with gravel developed over stony uplands. The rolling and undulating topography of the soil having 1.50 per cent slopes, resulting in soil erosion and water conservation problem. During the crop growth, maximum temperature was 38.8°C and minimum temperature was 17.2°C. Total precipitation during the season was 759.6 mm in 38 days. The experiment was conducted in a Randomized Block Design (RBD) with three replications. A promising chilli hybrid was used in all the three replications in a gross plot size of 5m x 4m with a row spacing of 75 cm and plant to plant distance of 50 cm. Two chilli seedlings of 45 days old were transplanted in each spot in all the three replications keeping 50 plants per plot for trial purpose. The recommended fertilizer dose of 100:50:60 N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha respectively was applied as per the university standard procedure. All the agronomic practices were done throughout the crop season. Three sprayings of Vitormone were done at 35, 55 and 75 days after transplanting by using high volume knapsack sprayer fitted with hollow cone nozzle. The treatment details are given below:-

Treatment No.	Treatment details	Dose ml/L
T-1	100% NPK (RDF)	At actual
T-2	100% NPK (RDF)+ Vitormone	100% NPK + 0.5
T-3	100% NPK (RDF)+ Vitormone	100% NPK + 1.0
T-4	100% NPK (RDF)+ Vitormone	100% NPK + 2.0
T-5	75% N + 100% P and K	75% N + 100% PK + 0.5
T-6	75% N + 100% P and K	75% N + 100% PK + 1.0
T-7	75% N + 100% P and K	75% N + 100% PK + 2.0
T-8	Control – Water spray	--

Vitormone is a foliar bio-fertilizer which has boosting effect on crop growth with various nitrogen fixing microbes which is produced by a patented technology. Vitormone contents syst forms of *Azotobacter chroococcum* bacteria and are suspension in clay based formation. All these dormant forms of bacteria germinate in the presence of oxygen, water and carbon source to form colonies of Vitormone bacteria. Colonies of these microbes produce amino acids, vitamins and PGPR which are absorbed immediately by the leaves. These beneficial bacteria increases the vegetative growth of the plant, healthy foliage, bumper flowering, reduces flower drop, increases healthy fruit set, improving fruit length and diameter, size and finally increasing in total yield (Inamdar et. al. 2000, Kanitkar and Kanitkar 2004, Deokar and Sawant 2005, Ghosh and Mohiuddin 2005). Similarly it is residue free, non toxic, organic certified and environmentally safe for spraying.

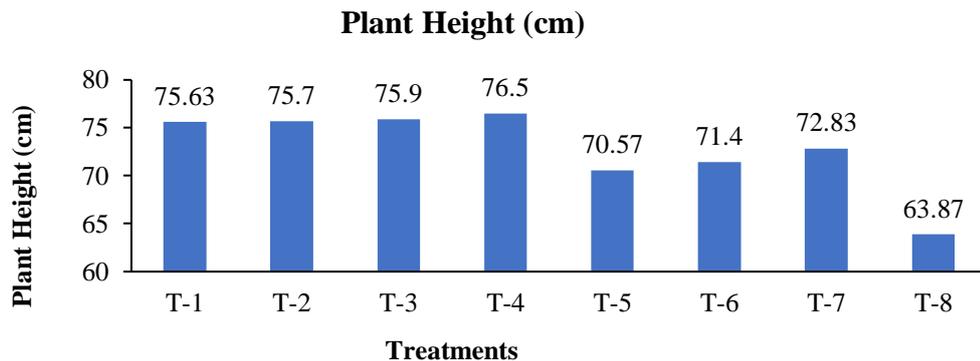
Results were collected from five representative plants selected randomly from each plot. Observations were recorded on plant height, number of branches per plant, days to maturity, fruit length, No. of fruits/plant and Green chilli yield (qtl/ha). All the data collected were statistically analyzed (ANOVA) according to the method suggested by Panse and Sukhatme (1985).

### III. RESULTS AND DISCUSSION

All the observations recorded on six morphological and yield contributing characters are given in Table-1 and Figures 1 to 2. Data compiled in Table-1 indicated that all the parameters were highly influenced by application of Vitormone. Significant findings are discussed below:-

#### i) Plant height (cm)

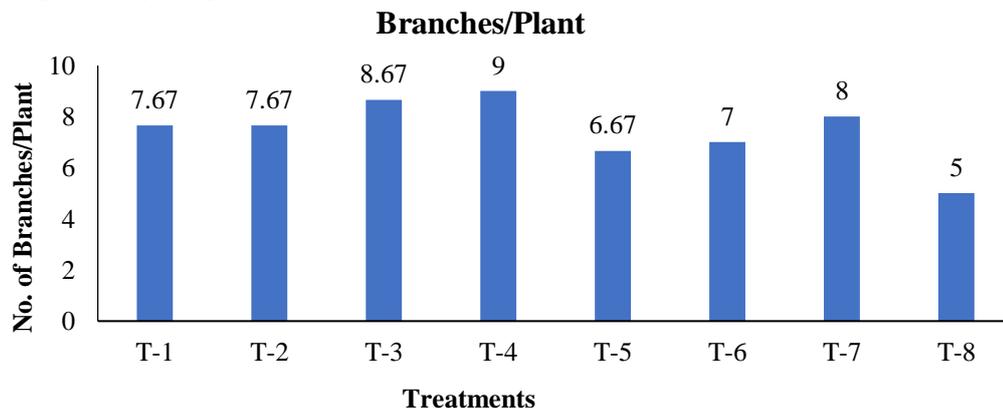
The plant height was measured from the base to the top of the plant in each treatment. In general, chilli crop influenced very well and statistically significant to the application of Vitormone at different concentrations and RDF alone and along with each other. Results revealed that plant height ranged from 63.87 cm (control) to 76.50 cm (T-4 treatment). Among all the treatments, application of RDF + Vitormone @ 2.0 ml/L at 35, 55 and 75 days after transplanting (T-4) recorded statistically significant maximum height (70.50 cm) followed by T-3 (75.90 cm), T-2 (75.70 cm), T-1 (75.63 cm), T-7 (72.83 cm), T-6 (71.40 cm) and T-5 (70.57 cm) over control (T-8).



#### ii) No. of branches/plant

The total number of branches/plant was counted in individual treatment at the time of physiological maturity/first picking of the fruits. The differences due to application of Vitormone in combination with RDF were statistically significant. RDF + Vitormone @ 2.0, 1.0 and 0.5 ml/L gave significantly highest number of

branches/plant i.e. 9.00, 8.67 and 7.67 respectively over control (5.00). All the above T-4, T-3, T-2 treatments gave 80.00%, 73.40% and 53.40% higher branches/plant over control treatment. Similarly, T-4 and T-3 treatments gave 17.34% and 13.03% respectively gave significantly higher branches/plant than T-1 (RDF) treatment.

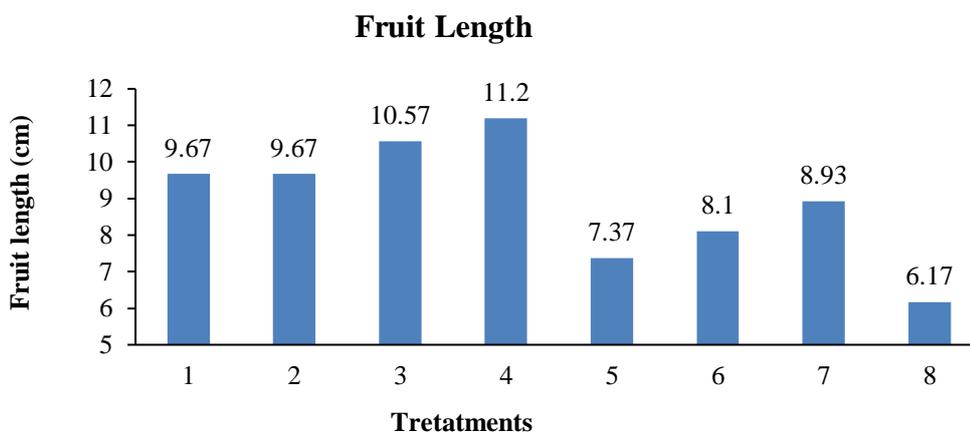


**iii) Days to maturity**

For days to maturity, application of Vitormone, RDF and 75% N and 100% PK along with their combinations significantly required more days to maturity than control treatment. T-4 treatment (RDF + Vitormone @ 2.0 ml/L) required maximum days to maturity (119.33 days) followed by T-3 (118.33 days), T-2 (117.67 days) and T-1 (117.00 days) as compared to control treatment (106.33 days). Even, T-4 and T-3 treatments required statistically significant more days to maturity than T-1 (RDF) treatment.

**iv) Fruit length (cm)**

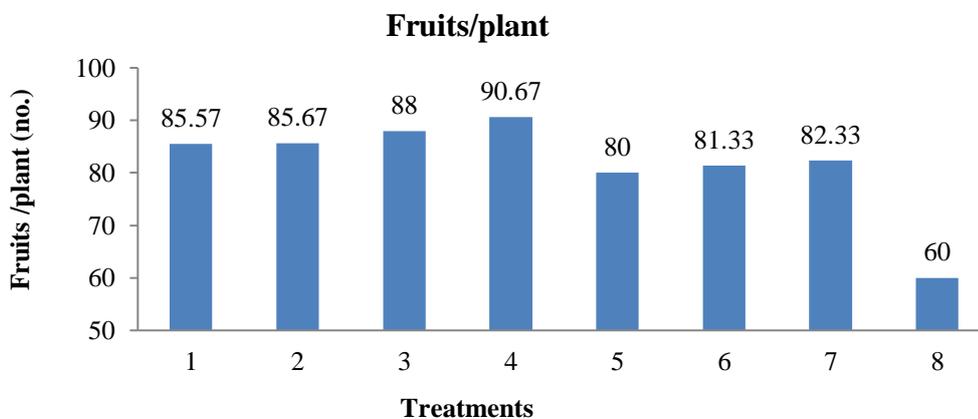
Application of RDF and Vitormone significantly increased fruit length. The combined application of RDF + Vitormone @ 2.0 ml/L (T-4) recorded significantly highest fruit length (11.20 cm) followed by T-3 (RDF + Vitormone @ 1.0 ml/L) with 10.57 cm, T-2 and T-1 (RDF) with 9.67 cm, T-7 (75% N + 100% PK + Vitormone @ 2.0 ml/L) with 8.93 cm. Likewise, T-4 (RDF + Vitormone @ 2.0 ml/L) and T-3 (RDF + Vitormone @ 1.00 ml/L) recorded significantly more fruit length viz. 15.82% and 9.30% than RDF (T-1) treatment. However, control treatment has recorded lowest fruit length (6.17 cm).



**v) Number of fruit/plant**

Normally chilli plants exposed to the high temperature reduced fruit set and their number. Foliar sprays with plant growth promoters (Vitormone) / NPK nutrients/bio- fertilizers increased the number of fruits/plant. In the present study RDF individually and along with different concentrations of Vitormone differ significantly for producing highest number of fruits/plant. The significantly highest number of fruit/plant (90.67) was observed in T-4 (RDF + Vitormone @ 2.0 ml/l)

treatment over RDF (T-1) treatment (85.67). However, other treatment viz. T-3 (88.00), T-2 and T-1 (85.67), T-7 (82.33), T-6 (81.33) and T-5 (80.00) gave significantly higher No. of fruits/plant than control treatment (60.00). T-4 treatment gave 51.12% more fruits/plant than control treatment followed by T-3 (46.67%), T-2 & T-1 (42.76%), T-7 (37.22%), T-6 (35.55%) and T-5 (33.33%) treatment. Even T-4 gave 5.84% more fruits than RDF (T-1) treatment.



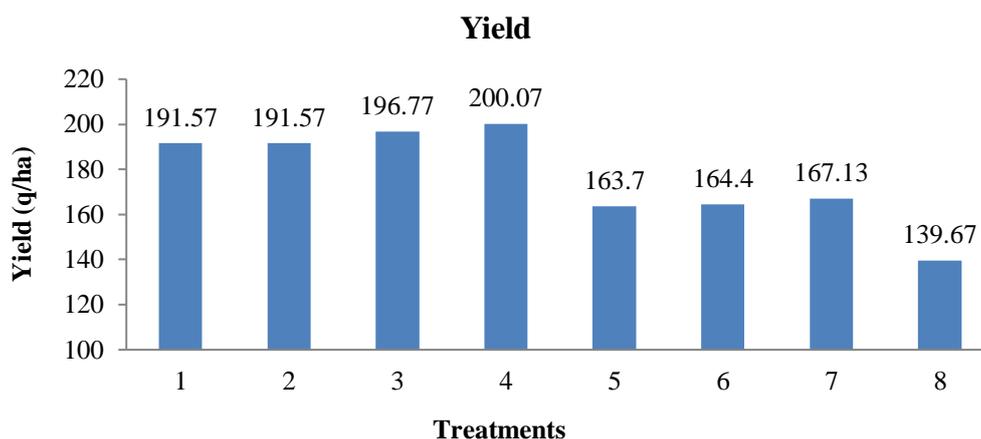
**vi) Green Fruit yield (q/ha)**

Statistically significant variation found due to application of Vitormone along with RDF in respect of yield per hectare. The maximum yield (200.07 q/ha) was

recorded from T-4 treatment (RDF + Vitormone @ 2.0 ml/L), while the minimum yield (139.67 q/ha) was recorded from control treatment. The significantly highest fruit yield (200.07 q/ha) was observed by T-4 treatment

followed by T-3 (RDF + Vitormone @ 1.0 ml/L) with 196.77 q/ha; T-2 and T-1 with 191.57 q/ha, T-7 with 167.67 q/ha, T-6 with 164.40 q/ha and T-5 with 163.70 q/ha as compared to control treatment. Even T-4 and T-3 treatments gave significantly more yield (4.44% and 2.24% respectively) than T-1 (RDF) treatment. Likewise, application of RDF + Vitormone @ 2.0 ml/L gave 43.24% higher yield followed by T-3 (RDF + Vitormone

@ 1.0 ml/L) with 40.88%, T-2 and T-1 with 37.16%, T-7 with 19.66%, T-6 with 17.71% and T-5 with 17.20% over control treatment. Application of Vitormone increases cell growth and elongation of cells which leads to bigger plants with longer shoots with higher crop yield. Similarly, the above results indicated that the higher concentrations of Vitormone along with RDF were more effective than the lower concentrations.



#### **Influence of Vitormone on phyto-toxicity**

The phyto-toxicity of Vitormone in chilli was not observed in respect of chlorosis, necrosis, wilting, scorching, hyponasty and epinasty at 35, 55 and 55 days after spraying.

In the present study, Vitormone (*Azotobacter chroococcum*) is a liquid bio-fertilizer with a boosting effect on crop growth and yield contributing characters. In order to increase and enhance quality and yield, a number of growth promoters, growth enhancers and growth regulating products (PGPR) have been applied to chillies. Bio-fertilizers have live formulations of beneficial micro-organisms such as fungal *Mycorrhizae*, *Rhizobium*, *Azotobacter*, *Azospirillum*, blue green algae, phosphate solubilizing bacteria (PSB), PGPR, *Pseudomonas* species and *Bacillus* spp. reported by Wu et. al. (2005), Choudhary et. al. (2013) and Nibhavatiet. al. (2008). Normally, all the above micro-organisms convert organic matter into simple compounds which provides plant nutrition, improves soil fertility, maintain original soil habitat and finally increases crop yield (Kennedy et. al. 2004). Among them, *Azotobacter* is capable of fixing an average 20 kg nitrogen per hectare during the cropping season (Kizilkaya, 2009). *Azotobacter* can also produce thiamin, riboflavin, indole acetic acid and gibberellins.

In the present study, it is significant, to note that Treatment No.4 (RDF + Vitormone @ 2.0 ml/ha) to be more promising since they increase plant height (19.77%), no. of branches/plant (80.00%), days to maturity (12.23%), fruit length (81.52%), number of fruits/plant (51.12%) and yield by 43.24%. Similarly, some treatment gave more plant height (1.15%), no. of branches/plant (17.34%), Fruit length (15.80%), number

of fruits/plant (5.84%) and yield (4.44%) over RDF also. These results are agree with those obtained by Kanitkar et. al. (2013), by using Vitormone (*Azotobacter chroococcum*) in cucumber, Raut et. al. (2014a, 2014b, 2016) in soybean, French bean and tomato, Ramteke et. al. (2016) in grapes. Earlier, in a detailed study on commercializing a new liquid bio-fertilizer technology first time in India, Kanitkar and Kanitkar (2004) reported that by using Vitormone (*Azotobacter chroococcum*) resulted in increased yield of various crops viz., wheat by 12.5 to 67.17%, paddy by 3.8 to 7.86, *Sorghum* by 43.56%, potato by 20.6%, sesame by 22.5%, maize by 20.8%, gram by 18.41%, sugarcane by 10.75%, groundnut by 13.73% and barley by 35.0% over control treatments.

Similarly, Kanitkar et. al. (2013) studied the effect of Vitormone on cucumber and reported that three sprayings along with RDF significantly increased fruit characters and yield by 23.5 to 30.75% over control. Similarly, Raut et. al. (2014b and 2016) studied the effect of Vitormone on French bean and tomato and reported that spraying @ 1.0 to 2.0 ml/L along with RDF significantly increase yield contributing characters and yield by 14.05% to 12.80% over RDF and 17.93 and 55.66% over control respectively. Similarly there was no any phyto-toxic effect on any part of the French bean or tomato. Earlier, Chandra et. al. (1979) have also reported that the nitrogen fixers are potential antifungal microorganisms of the phylloplane of certain crops such as paddy and jute. Even the soil application of bio-fertilizers has been reported to control foliar diseases (Sharma et. al. 1994) and Pests (Mohan et. al. 1987). Likewise, bio-fertilizers are cost effective and efficient source of nitrogen and phosphorus for the plants. Inamdar

(2000) reported that the traditional nitrogen fixing bio-fertilizers have suffered from problems of short life, instability to ambient temperature and laborious large-scale application or production. However, the cysts of *Azotobacter* in liquid formulation survives and retains the nitrogen fixing ability over two years.

In the present study, by using Vitormone along with RDF significantly increases morphological characters and yield. These reports are confirmative with the earlier reports of Srinivasan and Siddiqui (1992) who had reported that plant height, stem diameter, and yield of *Sorghum* were increased due to *Azotobacter* inoculations.

Likewise Gosh and Mohiuddin (2005) reported that the significant effect of bio-fertilizers viz. Vitormone®, Phosfert®, and Bioplin® on Sesame. They have also reported that the use of bio-fertilizers alone showed significant improvement in plant height, no. of branches/plant, no. of capsules/plant, no. of seeds/capsule, 100 seed weight and seed yield by 32.34% over control. Similarly, Deokar and Sawant (2005) reported that application of Vitormone (*Azotobacter* liquid inoculants) found effective in increasing plant height, stem diameter, crop growth rate, nitrogen content and yield in *Sorghum*.

**Table 1: Effect of Vitormone on growth and yield contributing characters in Chilli.**

Tr. No.	Treatments	Plant height (cm)	No. of branches/plant	Days to maturity	Fruit length (cm)	No. of fruits / plant	Fruit yield q/ha
T-1	RDF (100% NPK)	75.63* (18.41)	7.67* (53.40)	117.00* (10.03)	9.67* (56.73)	85.57* (42.78)	191.57* (37.16)
T-2	RDF + Vitormone 0.5 ml/L	75.70* (18.52)	7.67* (53.40)	117.67* (10.66)	9.67* (56.73)	85.67* (42.78)	191.57* (37.16)
T-3	RDF + Vitormone 1.0 ml/L	75.90* (18.84)	8.67** (73.40)	118.33** (11.29)	10.57** (71.31)	88.00* (46.67)	196.77** (40.88)
T-4	RDF + Vitormone 2.0 ml/L	76.50* (19.77)	9.00** (80.00)	119.33** (12.23)	11.20** (81.52)	90.67** (51.12)	200.07** (43.24)
T-5	75% N + 100% PK + Vitormone 0.5 ml/L	70.57* (10.49)	6.67* (33.40)	111.67* (5.02)	7.37* (19.45)	80.00* (33.33)	163.70* (17.20)
T-6	75% N + 100% PK + Vitormone 1.0 ml/L	71.40* (11.79)	7.00* (40.00)	113.00* (6.27)	8.10* (31.28)	81.33* (35.55)	164.40* (17.71)
T-7	75% N + 100% PK + Vitormone 2.0 ml/L	72.83* (14.03)	8.00* (60.00)	115.67* (8.78)	8.93* (44.73)	82.33* (37.22)	167.13* (19.66)
T-8	Control (water spray)	63.87	5.00	106.33*	6.17	60.00	139.67
	C.D.at 5%	1.02	0.98	1,22	0.83	2.49	3.15

( ) % increase over control, \* Significantly superior over control (T-8), \*\* Significantly superior over RDF (T-1).

#### IV. CONCLUSION

From the present study it may be concluded that three foliar sprayings of Vitormone @ 2.0 ml/L along with RDF at 35, 55 and 75 days after transplanting significantly increase in plant height, no. of branches/plant, fruit length, no. of fruits/plant and yield by 43.24% over control and 4.44% over RDF. Similarly, spraying of Vitormone @ 2.0 ml/L did not show any phytotoxic effect on chilli crop.

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