Journal of Dry Zone Agriculture, 2017, 3: 45 - 55

ISSN 2012 – 8673

Evaluation of Seed Biopriming and Organic Manures on Chilli Organic Seed Production

Ananthi, M.*, Selvaraju, P. and Sundaralingam, K.

Seed centre, Tamil Nadu Agricultural University, Coimbatore – 03

Abstract: To find out the effect of seed bio-priming with liquid bio-fertilizers and application of sources of nutrients on crop growth and yield of Chilli, a field experiment was conducted at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore on 2013 during *Kharif* and *Rabi* seasons. The results revealed that the plant growth and yield parameters were more in the plants grown from bio-primed seeds with *Azospirillum* than the non-primed seed. Among the sources of nutrients, the performance of inorganic fertilizer was higher than organic manures. Among the organic manures, seed bioprimed with *Azospirillum* and applied with poultry manure recorded the plant height of 66.2 and 63.9 cm, leaf area index of 1.665 and 1.621 and chlorophyll index of 44.9 and 43.9 in both the seasons. The same results were obtained with respect to number of flowers plant^{-1}, number of fruits plant^{-1} and fruit set percentage which were significantly higher in *Azospirillum* biopriming seed with inorganic fertilizer than organic treatments. The seed yield was high in the treatment involving seed bio-priming with *Azospirillum* and inorganic fertilizer (219.1 and 212.6 kgha^{-1}) followed by poultry manure (213.5 and 207.4 kgha^{-1}) than in the control (209.5 and 205.0 kgha^{-1}) in both the seasons.

Keywords: Chilli seed, Liquid biofertilizers, Organic manures

1. Introduction

The cultivable land resource is shrinking day by day with the increase in population. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Therefore, for sustaining the productivity of the crop, maintaining the soil health and healthy ecosystem, there is a need for adoption of an alternative system is organic farming. Organically grown products are expected to fetch higher price and this can offset any loss due to lower yield (Motsara, 2000). There is a greater demand in the international market for organically produced chilli. Since it is used almost daily in our food preparations as a spice. Chilli is a low-volume, high-

* Corresponding author email *: ananthiagri87@gmail.com* (M. Ananthi)

value seed. Since the seed costs are high, it is important for growers to obtain healthy, plantable seedlings from every seed sown. Delayed or erratic seedling emergences are serious problems that result in the production of non-uniform seedlings of low vigour in the nursery (Demir and Okeu, 2004). Faster emergences are essential pre-requisites for high quality seedling production, especially among transplanted vegetables. Sustainable crop production requires the adoption of eco-friendly seed enhancement techniques. One such treatment is seed bio-priming. Bio-priming is a seed pre-treatment that integrates the biological and physiological aspects of enhancing growth, improving disease control, and increasing yields.

A challenging task in organic seed production is the supply of balanced nutrition through organic manures. Unbalanced supply of nutrition may lead to nutrient deficiency and physiological disorders leading to poor growth and development, ultimately reduction of productivity. Technologies have been developed to produce large quantities of nutrient rich manure. It is understood that organic manures are rich in carbon fractions and their addition to the soil act as a source of energy for microbial population that encourages proliferation of soil microorganism, increased microbial populations and activity of microbial enzymes i.e., dehydrogenase, urease and nitrogenase (Bakry *et al.*,2009). Chilli crop responds well to the application of both organic manures and inorganic fertilizers. Organic manures in farming had advantages like nutrient conservation, slow releases and improvement in soil physical conditions and help in efficient nutrient management in a cropping system. Keeping the above research gaps in view, investigations were made by conducting field studies with chilli cv. PKM 1 with the objective of the effect of seed bio-priming with liquid bio-fertilizers and application of sources of nutrients on seed yield and quality.

2. Materials and Methods

Genetically pure, fresh seeds of chilli (PKM 1) obtained from the Department of Seed science and Technology, Tamil Nadu Agricultural University, Coimbatore formed the base material for this study. The liquid bio-fertilizers viz., Azospirillum and Phosphobacteria collected from the Department of Agricultural Microbiology, TNAU, Coimbatore-3 and farm yard manure, poultry manure and vermicompost obtained from the Department of Farm management and Animal Husbandry, TNAU, Coimbatore-3 also formed the materials for this study. In this experiment, chilli seeds bio-primed with liquid bio-fertilizers (*Azospirillum* 10 percent for 9h and phosphobacteria 15 percent for 9 h) and the non-primed (control) seeds were sown in protray and were transplanted in the main field 35 days after sowing. Field experiments were conducted by adopting split plot design with two replications in two seasons namely (*Kharif* 2013) and (*Rabi* 2013). The main plot treatments were bio-primed seed (*Azospirillum* 10 per cent for 9 h and phosphobacteria 15 per cent for 9 h) and non-primed seed (Ananthi *et al.*, 2014). There were seven sub plot treatments namely (i) recommended doses of NPK @ 60:30:30 kgha^{-1} (ii) 100 % RDF through farm yard manure (iii) 100 % RDF through poultry manure (iv) 100 % RDF through vermicompost (V) 50 % FYM + 50 % PM (vi) 50 % FYM + 50 % VC and (vii) 50 % PM + 50 % VC. The observations on growth and yield parameters were recorded from each treatment in replication wise.

2.1 Growth Parameters

Five plants were selected randomly from each treatment, replication wise for measuring the following observations.

Plant Height (cm): Height of the plant was measured from the ground level to the tip of the growing plant in five plants in each plot at 90 days after transplanting and mean value was expressed in centimetre.

Leaf Area Index: Leaf area was measured in randomly selected five plants at 90 days after transplanting and calculated using the following formula;

$$LAI = \frac{Leaf\ area\ per\ plant}{Ground\ area\ occupied\ by\ the\ plant}$$

Chlorophyll Index (SPAD values): Chlorophyll content was observed in randomly selected five plants at 90 days after transplanting at morning. Chlorophyll meter from Minolta (Model SPAD 502 of Co., Japan) was used to measure SPAD values (Anon., 1989). The third uppermost fully expanded leaf was measured and the mean value was worked out. SPAD meter (Konica, Minolta) was used to measure the chlorophyll content of the leaf. It quantifies green colour in plants immediately by non-destructive measuring method (Yadav, 1986). The chlorophyll meter calculated the SPAD value based on the intensities of light transmitted in the red band (around 650 nm) where absorption by chlorophyll is high and in the infrared band (around 940 nm) where absorption is low.

3.2 Yield and Yield Components

Number of Flowers: The total number of flowers from randomly selected five plants were counted and the mean values were expressed as number of flowers plant.

Number of Fruits: The number of fruits harvested in randomly selected five plants was recorded and the mean value expressed as number of fruits plant.

Fruit set Percentage: The fruit set percentage (FSP) was calculated by counting the number of flowers converted into fruits in randomly selected five plants in each plot as follows:

$$FSP = \frac{Number\ of\ fruits\ per\ plant}{Number\ of\ flowers\ per\ plant}$$

Fruit weight: The fruits harvested in each picking, treatment wise and replication wise in the randomly selected five plants were weighed and mean was expressed in gram.

Seed Yield: The well ripened fruits collected from each picking from the randomly selected plants were dried, and kept in paper bag. Seeds were extracted by beating the fruits with pliable sticks. Then, the seeds were sieved using BSS 8 × 8 sieve, and the seeds retained on the sieve were weighed and expressed in gram. Seeds extracted from the fruits harvested from each plot, treatment wise were dried and weighed. The seed yield was expressed in gram. Seed yield was calculated from the plot yield and expressed in $kgha^{-1}$

3.3 Statistical Analysis

The data obtained from various experiments were analysed statistically adopting the procedure described by Panse and Sukhatme (1985). Wherever necessary, the percent values were transformed to angular (arcsine) values before analysis. The critical differences (CD) were calculated at 5 percent probability level. The data were tested for statistical significance. If the F test is non-significant, it was indicated by the letters NS.

4. Results and Discussions

4.1 Growth Parameters

Statistically significant differences were observed for the growth parameters with bio-priming treatments. Among the main plot treatments, seeds bio-primed with 10 per cent *Azospirillum* for 9 h recorded maximum plant height (64.2 and 62.0 cm), leaf area index (1.611 and 1.499) and chlorophyll index (43.4 and 42.6) at 90 days after transplanting than non-primed seeds in both the seasons. Among the sub plot treatments, plant height (66.2 and 64.9 cm), leaf area index (1.659 and 1.665) and chlorophyll index (45.7 and 44.5) were also more in the plants grown from the bio-primed seed with *Azospirillum* and applied with recommended dose of fertilizer when compared to non-primed seed with respect to plant height (64.8 and 64.0 cm), leaf area index (1.639 and 1.642) and chlorophyll index (42.8 and 40.9). Among the organic manures, seed bio-primed with *Azospirillum* and basal application with poultry manure recorded the plant height of 66.2 and 63.9 cm, leaf area index of 1.665 and 1.621 and chlorophyll index of 44.9 and 43.9 outperforming others in both the seasons (Table 1 and 2).

Significant increase in plant height may be attributed to more nitrogen fixation by *Azospirillum* isolates that can be used by the plant (Rodrigues *et al.*, 2008) and production of phyto-hormones like indole-3-acetic acid, indole-3-butyric acid, gibberellic acid and cytokinin (Fallik *et al.*, 1988; Bottini *et al.,* 1989). Improvement in growth parameters due to *Azospirillum* treatment to the seeds recorded in this study is in agreement with results of Kanimoli *et al.* (2004), Santa *et al.* (2004), El-Kholy *et al*. (2005), Gomathy *et al.* (2007), Puenette *et al*. (2009) and Yadav *et al.* (2011b) in maize and Diaz – Zortia and Fernandez – Canigia (2009) and Yadav *et al.* (2011a) in wheat.

Table 1: Effect of seed biopriming and source of organic nutrients on plant height (cm), leaf area index and chlorophyll index at 90 DAT in chilli cv. PKM 1 in *Kharif* 2013

Main plot / Subplot treatments	Plant height (cm)				Leaf area index				Chlorophyll index			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
RDF (Inorganic) (S_1)	64.8	67.8	66.1	66.2	1.64	1.68	1.66	1.66	42.8	45.7	44.3	44.3
100% farmyard manure (S_2)	58.5	60.0	59.2	59.2	1.51	1.51	1.49	1.50	39.5	41.0	40.2	40.2
100% poultry manure (S_3)	63.1	66.2	64.9	64.7	1.62	1.67	1.64	1.64	41.6	44.9	44.0	43.5
100% vermicompost (S_4)	62.7	65.5	64.0	64.1	1.61	1.66	1.64	1.64	41.5	44.1	43.2	42.9
50% FYM+50% PM (S_5)	60.3	63.1	61.6	61.7	1.55	1.58	1.55	1.56	40.9	42.6	41.5	41.7
50% FYM+50% VC (S_6)	59.2	61.9	60.7	60.6	1.53	1.53	1.53	1.53	40.3	41.8	40.9	41.0
50% PM+50% VC (S_7)	62.0	64.9	63.2	63.4	1.57	1.65	1.58	1.60	41.1	43.7	42.9	42.6
Mean	61.5	64.2	62.8		1.58	1.61	1.58		41.1	43.4	42.4	
	M	T	M×T	T×M	M	T	M×T	T×M	M	T	M×T	T×M
SEd	0.25	0.46	0.78	0.80	0.002	0.002	0.004	0.003	0.091	0.100	0.185	0.174
CD (P=0.05)	0.50	0.92	1.56	1.60	0.005	0.004	0.007	0.006	0.184	0.205	0.372	0.350

RDF- Recommended dose of fertilizer- 60:60:30 kg NPK ha^{-1}, M_1- Nonprimed seeds; M_2 - Biopriming with *Azospirillum* 10 % for 9h; M_3 - Biopriming with Phosphobacteria 15 % for 9 h , ; DAT-Days after transplanting, SEd- Standard error of deviation, CD- Critical difference

Table 2: Effect of seed biopriming and source of organic nutrients on plant height (cm), leaf area index and chlorophyll index at 90 DAT in chilli cv. PKM 1 in *Rabi* 2013

Main plot / Subplot treatments	Plant height (cm)				Leaf area index				Chlorophyll index			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
RDF (Inor-ganic) (S_1)	64.0	65.7	64.9	64.9	1.642	1.695	1.659	1.665	40.9	44.5	43.2	42.9
100% farmyard manure (S_2)	57.0	58.2	57.9	57.7	1.251	1.306	1.282	1.280	37.2	40.9	39.6	39.2

100% poultry manure (S_3)	61.9	63.9	63.1	63.3	1.540	1.621	1.585	1.582	40.1	43.9	42.7	42.2
100% vermicom-post (S_4)	61.0	63.2	62.3	62.2	1.515	1.560	1.527	1.534	39.3	40.3	41.9	41.4
50% FYM+50% PM (S_5)	59.6	61.0	60.1	60.2	1.427	1.421	1.406	1.418	38.1	42.1	40.6	40.3
50% FYM+50% VC (S_6)	57.0	59.7	58.5	58.4	1.389	1.397	1.325	1.370	37.7	41.4	40.1	39.7
50% PM +50% VC (S_7)	61.2	61.5	60.9	61.2	1.472	1.495	1.472	1.480	38.7	42.7	41.0	40.8
Mean	60.2	62.0	61.1		1.462	1.499	1.465		38.8	42.6	41.3	
	M	T	M×T	T×M	M	T	M×T	T×M	M	T	M×T	T×M
SEd	0.181	0.293	0.503	0.507	0.0035	0.0018	0.0046	0.0032	0.128	0.321	0.531	0.556
CD (P=0.05)	0.368	0.589	1.010	1.016	0.0070	0.0039	0.0092	0.0065	0.259	0.645	1.065	1.115

RDF- Recommended dose of fertilizer- 60:60:30 kg NPK ha^{-1}, M_1- Nonprimed seeds; M_2 – Biopriming with *Azospirillum* 10 % for 9 h; M_3 – Biopriming with Phosphobacteria 15 % for 9 h, DAT–Days after transplanting, SEd–Standard error of deviation, CD–Critical difference

Inorganic fertilizers recorded maximum growth parameters because inorganic fertilizers might have promoted the N uptake essential for efficient photosynthesis and faster growth rate resulting in increased plant height. This is in conformity with the earlier findings of Raja (2003), Sundaralingam (2005) and Vijayan (2005) in hybrid rice. The promotive effect of nitrogen and phosphorous on plant height may be due to the better synthesis of amino acids which help in cell multiplication and elongation.Inorganic fertilizers might have improved photosynthetic activity resulted in increased synthesis and translocation of photosynthates in the plants and subsequently higher dry matter content of the plant (Wange and Kale, 2004).

In organic seed production, application of poultry manure to the bioprimed seed could able to contribute added advantage in increasing the growth parameters.The positive effect of organic manure on plant height could be due to the contribution made by manure to the fertility status of the soils as the soils were low in organic carbon content. Increased plant height as a result of poultry manure was due to the presence of high phosphorus content which increased the availability of native soil phosphorus and increased biological activity (Adilakshmi *et al,* 2008). The results are in conformity with the results of Yadav *et al.*, (2004) and Karthika (2013) in okra. Poultry manure was readily available and in the best form for easy absorption by the plant roots, hence there was a boost in the morphological growth of the plant.

3.2 Yield Parameters

In the present study, fruit set percentage (82.6 and 81.5) and seed yield (219.1 and 212.6 kg ha^{-1}) was more due to seeds bio-primed with Azospirillum grown under inorganic fertilizer. Among the organic manures, seed bio-primed with *Azospirillum* and applied with poultry manure recorded the fruit set percentage of 81.0 and 79.6 and seed yield of 213.5 and 207.4 kg ha^{-1} outperforming others in both the seasons (Table 3 and 4).

Table 3 : Effect of seed biopriming and source of organic nutrients on fruit set percentage (%) and seed yield plant^{-1} (g) and seed yield ha^{-1} (kg) in organic seed production in chilli cv. PKM 1 in *Kharif* 2013

Main plot / Subplot treatments	Fruit set percentage (%)				Seed yield / plant (g)				Seed yield / ha (kg)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
RDF (Inorganic) (S_1)	80.2	82.6	81.0	81.3	8.50	8.97	8.78	8.75	209.5	219.1	215.5	214.7
100% farmyard manure (S_2)	69.3	72.9	69.6	70.6	7.52	7.79	7.65	7.65	164.2	174.5	172.4	170.4
100% poultry manure (S_3)	79.0	81.0	79.6	79.9	8.33	8.50	8.42	8.42	210.1	213.5	211.0	211.5
100% vermicompost (S_4)	76.3	79.4	77.1	77.6	8.05	8.29	8.15	8.16	201.5	205.5	203.0	203.3
50% FYM+50% PM (S_5)	72.2	75.9	73.9	73.9	7.84	8.00	7.96	7.93	183.5	195.3	188.2	189.0
50% FYM+50%VC (S_6)	70.5	74.4	71.0	71.7	7.75	7.94	7.90	7.86	176.0	187.2	179.5	180.9
50% PM+50%VC (S_7)	74.8	78.0	75.3	76.0	7.95	8.14	8.06	8.05	194.5	200.1	197.0	197.2
Mean	74.6	77.6	75.4		7.99	8.23	8.13		191.3	199.3	195.2	
	M	T	M×T	T×M	M	T	M×T	T×M	M	T	M×T	T×M
SEd	0.102	0.402	0.352	0.396	0.019	0.031	0.053	0.054	0.071	0.257	0.418	0.445
CD (P=0.05)	0.205	0.805	0.704	0.792	0.041	0.065	0.108	0.113	0.145	0.519	0.841	0.892

RDF- Recommended dose of fertilizer- 60:60:30 kg NPK ha^{-1}, M_1- Nonprimed seeds; M_2 - Biopriming with *Azospirillum* 10 % for 9 h; M_3 - Biopriming with Phosphobacteria 15 % for 9 h SEd- Standard error of deviation, CD- Critical difference

Table 4 : Effect of seed biopriming and source of organic nutrients on fruit set percentage (%) and seed yield plant $^{-1}$ (g) and seed yield ha^{-1} (kg) in organic seed production in chilli cv. PKM 1 in *Rabi* 2013

Main plot / Subplot treatments	Fruit set percentage (%)				Seed yield / plant (g)				Seed yield / ha (kg)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
RDF (Inorganic) (S_1)	79.4	81.5	80.7	80.5	8.40	8.92	8.68	8.67	205.0	212.6	210.9	209.5
100% farmyard manure (S_2)	69.4	72.1	71.9	71.1	7.49	7.70	7.62	7.60	166.1	171.8	168.9	168.9
100% poultry manure (S_3)	76.5	79.6	78.9	78.3	8.15	8.32	8.28	8.25	204.0	207.4	205.0	205.5
100% vermicom post (S_4)	74.8	78.4	77.5	76.9	8.01	8.25	8.19	8.15	198.0	200.9	199.0	199.3
50% FYM+50% PM (S_5)	71.1	75.5	74.8	73.9	7.81	7.99	7.95	7.92	183.9	191.8	187.4	187.7
50% FYM+50% VC (S_6)	70.6	73.6	73.2	72.7	7.77	7.92	7.89	7.86	174.9	179.8	177.3	177.3
50% PM+50% VC (S_7)	73.7	76.7	75.5	75.3	7.93	8.10	8.05	8.03	191.8	197.0	193.9	194.2
Mean	73.6	76.9	76.1		7.94	8.17	8.09		189.1	194.5	191.8	
	M	T	M×T	T×M	M	T	M×T	T×M	M	T	M×T	T×M
SEd	0.187	0.188	0.355	0.325	0.004	0.012	0.020	0.021	0.203	0.421	0.706	0.730
CD (P=0.05)	0.380	0.379	0.711	0.652	0.010	0.026	0.045	0.045	0.410	0.849	1.419	1.465

RDF– Recommended dose of fertilizer- 60:60:30 kg NPK ha^{-1}, M_1– Nonprimed seeds; M_2 – Biopriming with *Azospirillum* 10 % for 9 h; M_3 – Biopriming with Phosphobacteria 15 % for 9 h , SEd- Standard error of deviation, CD– Critical difference

The possible reason for increase in number of fruits per plant in Azospirillum may be attributed to the production of various endogenous hormonal levels in the plant tissues that may enhance the pollen germination and tube growth which ultimately, may increase the fruit set per plant (Balasubramanian, 1988). The fruit set percentage were increased due to the production of more number of branches per plant (Gosavi *et al.*, 2011) due to the immediate availability of nutrients to the plants from inorganic source.

The increase in seed yield observed in the present study due to growth substances produced by *Azospirillum* might have accelerated the carbohydrate accumulation and increased metabolic activities leading to heavy seed weight and higher seed yield (Singh *et al.*, 2003). It was observed that *Azospirillum* inoculation significantly increased the yield of several crops upto 30 % (Sumner, 1990; Okon and Labandera Gonzalez, 1994; DallaSanta *et al.*, 2004). The best performance in terms of seed yield with the application of inorganic fertilizer might be due to the availability of optimum dose of nutrients to plant to complete and maintain its physiology (Kunzanglamo *et al.*, 2012). Similar results were also reported by Malik *et al*. (1988) in mung bean and Srinivas and Shaik (2002) in greengram. However, inorganic plot received P and K at a dose of 60 and 30 kg ha^{-1}, respectively, whereas organics might not supply the required quantity of P and K to the plants and that could be one of the reasons for the superiority of inorganic plots.

4. Conclusions

It is concluded that, seed bio-priming with *Azospirillum* 10 per cent for 9h along with 100 per cent RDF through poultry manure was the best treatment for organic manure nutrition.

References

Adilakshmi, A., Korat, D.M and Vaishnav, P.R. 2008. Bio-efficacy of some botanical insecticides against pests of okra. Karnataka Journal of Agricultural Sciences. 21: 290-292.

Ananthi, M., Selvaraju, P. and Sundaralingam, K. 2014. Study of biopriming using liquid biofertilizers in chilli cv PKM 1 seeds. Environment and ecology. 32 (3A): 1172-1177.

Bakry, M.A., Paraas, M.M. and Abass, M.M. 2009. Effect of organic and inorganic soil ammendements combined with mineral fertilizers on the fertility of calcareous soil and its productivity. Minufiya Journal of Agricultural Research. 34 (6): 2243-2260.

Balasubramanian, P. 1988. Studies on the effect of *Azospirillum* and nitrogen on growth and yield of bhendi (*Abelmoschus esculentum* L. Moench) var. Pusa sawani. South Indian Horticulture. 36: 216-217.

Bottini, R., M. Fulchieri, D. Pearce and R.P. Pharis. 1989. Identification of gibberellins A1, A3 and iso - A3 in cultures of *Azospirillum lipoferum.* Plant Physiology. 90: 45-47.

Dalla Santa, O.R., R.F. Hernández and L. Gergina. 2004. *Azospirillum* sp. inoculation in wheat, barley and oats seeds greenhouse experiments.Braz. Brazilian Archives of Biology and Technology.47 (6): 843-850.

Demir, I. and Okeu,G. 2004. Aerated hydration treatment for improved germination and seedling growth in aubergine (*Solanum melongena*) and pepper (*Capsicum annuum*). Annals of Applied Biololgy. 144: 121-123.

Diaz - Zortia, M. and M.V. Fernandez - Canigia. 2009. Field performance of a liquid formulation *Azospirillum brasilense* on dryland wheat productivity. Europe Journal of Soil Biology. 45: 3-11.

El-Kholy, M.A., El-Ashry, S. and Gomaa, A.M.. 2005. Biofertilization of maize crop and its impact on yield and grains nutrient content under low rates of mineral fertilizers. Journal of Applied Scientific Research. 1 (2):117-121.

Fallik, E., Okon, Y. and Fischer, M. 1988. Growth response of maize roots of Azospirillum inoculation: effect of soil organic matter content, number of rhizosphere bacteria and timing of inoculation. Soil Biol. Biochem., 20: 45−49.

Gomathy, M., Thangaraju, M., Gopal, N.O. and Sarathambal, C. 2007. Comparative performance of liquid formulation of phosphobacteria with carrier based inoculants on the growth and yield of maize (CO 1). Journal of Soil Biology. 27:7-12.

Gosavi, P.U., Kamble, A.B. and Pandure, B.S. 2011. Effect of organic manures with biofertilizer on yield contributing characters of tomato. International Journal of Agricultural Science. 7(1): 51-53.

Kanimoli, S., Umamaheswari, T. and Thangaraju. M. 2004. Cyst induction in *Azospirillum* and regeneration of cyst cells. Paper presented in the National Symposium on Microbial Technology for productive Agriculture, TNAU, Coimbatore. (Extended summary) 299.

Karthika. C. 2013. Development of technologies for organic bhendi (*Abelmoschus esculentus* L. moench) seed production. Ph.D.Thesis. Tamil Nadu Agricultural University. Coimbatore. India.

Kunzanglamo, B., Korla, N. and Shukla, Y.R. 2012. Effect of different organic and inorganic nutrient sources on seed production of Radish. Life Science Leaflets. 2: 38-44

Malik M.A, Iqbal, R.M. and Ayyoub, M. 1988. Seed yield and quality of mungbean as influenced by NPK application. Pakistan Journal Agriculture Science. 25: 95-96.

Motsara, M.R. 2000. Plant nutrients. Role of micronutrients. The Hindu Survey of Indian Agriculture. p. 179.

Okon, Y. and Labandera-González, C. 1994. Agronomic applications of Azospirillum: an evaluation of 20 years of worldwide field inoculation. Soil Biology and Biochemistry. 26: 1591-1601.

Panse, V.G. and Sukhatme, P.V. 1985. In: Statistical methods for agricultural workers. ICAR.

Puenete, M. L., Garcia, J.E. and Alejandro, P. 2009. Effect of the bacterial concentration of *Azospirillum brasilense* in the inoculums and its plant growth regulator compounds on crop yield of corn (*Zea mays*) in the field. World Journal of Agriculture Science. 5(5): 604-608.

Raja, K. 2003. Investigations on nursery and main field management techniques for quality seed production of hybrid rice CORH2. Ph.D. Thesis submitted to Tamil Nadu Agricultural University, Coimbatore.India.

Rodrigues, E.P., Rodrigues, L.S., De Oliveira, A.L.M., Baldani, V.L.D., Teixeira, K.R.D., Urquiaga, S. and Reis, V.M. 2008. *Azospirillum amazonense* inoculation: Effects on growth, yield and N2 -fixation of rice (*Oryza sativa* L.). Plant and Soil. 302: 249-261.

Santa, O. R. D., Soccol, C. R., Junior, P. R., Hernández, R. F., Michelena Alvarez, G. L., Herta, S. Santa, S.D and Pandey P.A. 2004. Effects of inoculation of *Azospirillum* sp in maize seeds under field conditions. Food Agriculture Environment. 2 (1): 238-242.

Singh, P.V., Panwar, S. and Kumar, J. 2003. Response of tuberose to plant growth regulators, Journal of Ornamental Horticulture. 6 (1): 80-81.

Srinivas, M and Shaik, M. 2002. Performance of greengram and response function as influenced by different levels of nitrogen and phosphorus. Field Abstracts. 56 (5).

Sumner, M. E. 1990. Crop responses to *Azospirillum*. Advanced in Soil Science. 12: 53-123.

Sundaralingam, K. 2005. Organic seed production in hybrid rice ADTRH1. Ph.D thesis submitted to Tamil Nadu Agricultural University, Coimbatore.India.

Vijayan, R. 2005. Organic seed production in rice cv. ADT 43. Ph.D Thesis. Tamil Nadu Agricultural University, Coimbatore. India.

Wange, S. S. and Kale, R. H. 2004. Effect of bio-fertilizers under graded nitrogen levels on brinjal crop. Journal of Soils and Crops. 14 (1): 9-11.

Yadav, P., P. Singh, R.L. and Yadav, R. L. 2004. Ameliorative organic manures and nitrogen levels on okra. Haryana Journal of Horticulture Science. 25.

Yadav, J., Yadav, S. and Singh, S. G. 2011a. Plant growth promotion in wheat crop under environmental condition by PSB as biofertilizer. Research Journal in Agriculture Science. 2(1):76-78.

Yadav, S., Yadav, J. and S.G. Singh. 2011b. Performance of *Azospirillum* for improving growth, yield and yield attributing characters of maize (*Zea mays*. L) in presence of nitrogen fertilizer. Research Journal in Agriculture Science. 2 (1):139-141.