Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 8 [1] December 2018 : 09-17

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

REVIEW ARTICLE **OPEN ACCESS**

Efficacy of Biofertilizers to improve Flower Production: A review

***Gawade Nagesh Vithu[1], Varu D. K.[2], Dishaben Patel[3], Aghera Sameer R.[4]**
[1 & 3]Ph.D. Scholar, Junagadh Agricultural University, Junagadh- 362001
[2]Professor, Junagadh Agricultural University, Junagadh- 362001
[4]Research Associate, Junagadh Agricultural University, Junagadh- 362001
Correspondence author: Mail id: nageshgawade777@gmail.com

ABSTRACT
Biofertilizers or more appropriately called "microbial inoculants" are the preparations containing live or latent cells of efficient strains of microorganisms. When biofertilizers are applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Common biofertilizers used in horticultural crops are Azotobacter, Azospirillum, *Phosphate Solubilizing Bacteria (PSB), Potash Solubilizing Bacteria (KSB) and Vesicular-arbuscular Mycorrhiza (VAM) fungi. They add nutrients through the natural processes of fixing atmospheric nitrogen, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances.To minimize the use of chemical fertilizers we are now directing ourselves towards the potential use of ecofreindly approaches such as the use of biofertilizers to sustain high production, allow more efficient nutrient utilization and thereby provide solutions for present and future agricultural practices. In this review article a brief overview on the potential use of "Biofertilizers" for betterment of quality flower production is being discussed.*
Key words: Biofertilizers, bio inoculants, flower crops.

Received 12.08.2018 Revised 26.09.2018 Accepted 01.11.2018

INTRODUCTION

Flowers are nature's beloved gift to mankind. Their importance from aesthetic, environmental, economic and medicinal point of view cannot be under estimated. Yet all flowers are not equally admired, preferences vary from period of history, person to person and also depends on place. The flowers like rose, chrysanthemum, gladiolus, carnation, gerbera, tuberose, orchid, anthurium, lilies etc. have commonly and frequently used for many purposes in both the local as well as international market. It is said that man is born with flowers, lives with flowers and finally dies with flowers. The scope of utility and importance of flowers have been realized throughout the world and in this modern age, floriculture has developed into a profitable industry in the recent years both for domestic and export market. Floriculture has tremendous potential for export beside domestic consumption.

The biofertilizers are cost effective renewable energy source and play a crucial role in reducing the inorganic chemical or fertilizer application and at the same time increasing the flowering growth, quality and yield of flowers. Indiscriminate and term use of chemical fertilizers has not only led to imbalance of nutrients in soil resulting in degradation of soil structure but has also affected the growth and production of flowers [1, 2]. Now days, a lot of emphasis is being paid on the use of bio-fertilizer to increase the production of flower crops. Biofertilizer usually consists of live or latent cells of micro-organisms which include biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements into available forms.

WHAT IS BIOFERTILIZERS?

The term "biofertilizer" has been defined as different ways over the past 20 years, which derives from the improved understanding of the relationships occurring between the rhizosphere microorganisms and the plant. Biofertilizers may be defined as "substances which contain living microorganisms that colonize the rhizosphere or the interior of the plants and promote growth by increasing the supply or availability of primary nutrients to the target crops, when applied to soils, seeds or plant surfaces". According to Vessey

[3], the term biofertiliser is associated to "a substance which contains living microorganisms which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant". In 2005, biofertilizer was defined as "a product that contains living microorganisms, which exert direct or indirect beneficial effects on plant growth and crop yield through different mechanisms".

Bio-fertilizers are natural fertilizers which are the preparations containing living cells of microorganism which when inoculated into soil provide essential nutrients to plants. Biofertilizers are biologically active products containing certain strains of bacteria, algae or fungi, as a single or composite culture. They produce hormones and anti metabolites which promote root growth. They decompose organic matter and help in mineralization in soil. When applied to seed or soil, biofertilizers increase the availability of nutrients and improve the yield by 10 to 25 % without adversely affecting the soil and environment. Biofertilizers replace 25-30 % chemical fertilizers, increase the yields by 10-40%, decompose plant residues, and stabilize C:N ratio of soil. It's also Improve texture, structure and water holding capacity of soil. It involves inoculation of beneficial microorganisms that help nutrient acquisition by plants through fixation of nitrogen, solubilization and mobilization of other nutrients [4].

Biofertilizers are preparations containing cells of microorganisms which may be nitrogen fixers, phosphorus solublizers, sulphur oxidizers or organic matter decomposers. They are called as bioinoculants-bacteriumor fungi which on supply to plant improve their growth and yield [5].

Positives of Biofertilizers

The innovative view of farm production attracts the growing demand of biological based organic fertilizers exclusive of alternative to agro-chemicals [6]. Organic farming is one of such strategies that not only ensures food safety but also adds to the biodiversity of soil [7]. The additional advantages of biofertilizers include longer shelf life causing no adverse effects to ecosystem [8]. Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients via nitrogen fixation, phosphate and potassium solubalisation or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil [9]. When biofertilizers are applied as seed or soil inoculants, they multiply and participate in nutrient cycling and benefit crop productivity [10]. In general, 60% to 90% of the total applied fertilizer is lost and the remaining 10% to 40% is taken up by plants. In this regard, microbial inoculants have paramount significance in integrated nutrient management systems to sustain agricultural productivity and healthy environment [11]. Poorly managed use of these chemical N and P fertilizers have created several environmental problems such as deterioration of soil quality, leaching, acidification, denitrifiction, air pollution, reduced biodiversity, disrupting the fragile ecosystem [12, 13]. So the use of biofertilizers is the way to overcome the severe effects of chemical fertilizers. Emerging importance of bio-fertilizers will decrease the requirement of synthetic fertilizers and in result it will be helpful in the restoration of environment [14]. Option of bio-fertilizer is getting very popular as a choice for the replacement of synthetic fertilizer lowering the cost of crop production, enhancing the growth, development and crop yield by supplying and increasing the nitrogen availability and by producing certain substances like auxin, cytokinin and gibberellins, which are helpful in the growth of plants [15, 16]. The use of organic manures and biofertilizers along with balanced use of chemical fertilizers is known to improve the physico-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers [17].

APPLICATION OF MICROBIAL BIOFERTILIZER

Application of the microbial biofertilizer is an important step in the Biofertilizer Technology. If the microbial inoculant is not applied properly, the benefits from the biofertilizer may not be obtained. During application one should always remember that the most of the microbial biofertilizers are heterotropic, i.e. they cannot prepare their won food and depend upon the organic carbon of soil for their energy requirement and growth. So, they either colonise in rhizosphere zone or live symbiotically within the root of higher plants. The bacteria which are colonised in the rhizosphere zone obtain their organic carbon compounds from the root exudes of the higher plants. The symbiotic ones obtain organic carbon directly from the root. So, microbial inoculants must be applied in such a way that the bacteria will be adhered with the root surface. So, in case of transplanting crops, the inoculant are applied through roots, and in case of the crops in which seeds are sown directly in the field, the inoculants are applied through the seeds so that they can colonize in the rhizosphere region when the young roots are emerged after germination of seed [18].

On the basis of the above principal, the following inoculation methods has been developed: 1. Inoculation of the seeds by slurry inoculating technique 2. Inoculation of seeds by seed pelleting technique 3. Inoculation of the seedlings 4. Inoculation of the soil by solid inoculation technique [19]. The application of biofertilizer increases the population of microorganisms that transform plant nutrients to the available form in soil [3].

Classification of biofertilizers:

S.N.	Groups		Examples
A	**N_2 fixing Biofertilizers**		
	1.	Free living	*Azotobacter, Clostridium, Anabaena, nostoc*
	2.	Symbiotic	*Rhizobium, Anabaena azollae*
	3.	Associative symbiotic	*Azospirillum*
B	**P Solubilising Biofertilizers**		
	1.	Bacteria	*Bacillus subtilis, Pseudomonas striata*
	2.	Fungi	*Penicillium sp., Aspergillus awamori*
C	**P Mobilizing Biofertilizers**		
	1.	Arbuscular Mycorrhiza	*Glomus Sp., Scutellospora sp.*
	2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp*
	3.	Ericoid Mycorrhiza	*Pezizella ericae*
D	**Biofertilizers for micro nutrients**		
	1.	Silicate and Zinc solubilizers	*Bacillus sp.*
E	**Plant Growth Promoting Rhizobacteria**		
	1.	Pseudomonas	*Pseudomonas fluorescence*

How do biofertilizers work?

- Biofertilizers fix atmospheric nitrogen in the soil and root nodules of legume crops and make them available to the plants.
- They solubilize the insoluble forms of phosphate, such as tricalcium, iron and aluminum phosphates, into available forms.
- They scavenge phosphates from soil layers.
- They produce hormones and anti-metabolites which promote root growth.
- They decompose organic matter and help in the mineralization of soil.
- When applied to the soils or seeds, these biofertilizers increase the availability of nutrients and improve the yield by 10% to 20% without adversely affecting the soil and the environment.

EFFECT OF BIOFERTILIZERS ON GROWTH, YIELD AND QUALITY:

Anthurium

The effect of biofertilizers (*Azospirillum,* Phosphobacteria and VAM) along with inorganic nutrients (30:10:10, 30:5:10, 30:0:10, 15:10; 10, 15:5; 10 and 15:0:10 NPK, each at 0.2 per cent spray) and growth regulator (GA_3 @ 200 ppm) on floral characters and vase life of anthurium cv. Temptation was obvious. The treatment receiving all the three biofertilizers along with full dose of inorganic nutrient and GA_3 recorded highest vase life and improved floral characters indicating the effect of biofertilizers on the qualitative character of anthurium [20].

Calendula

Shasidhara and Gopinath [21] noted that the significantly tall statured plants (19.60 cm), higher number of branches (8.87/plant), higher number of leaves (49.30/plant), extension of longevity of flowers on the plant (by 2.5 days), duration of flowering (by 4 days), higher yield of flowers in terms of number (19.67 /plant) and weight (72.20 g/plant and 14.46 t/ha), larger flowers (6.80 cm), longer flower stalks (7.27 cm) and vase life (5.33 day) obtained with application of 135:90:60 kg N, P2O5 and K2O/ha + *Azotobacter* @ 200 g/ha and VAM @ 15.6 g/plant in calendula. Singh *et al*. [22] observed that the application of *Azotobacter* + PSB + 75 % N/ha was found better with respect to plant growth, maximum production of fresh flowers (134.38 q/ha) and prolonged the duration of flowering in calendula (*Calendula officinalis* L.).

Carnation

Bhalla *et al*. [23] evaluated that carnation cultivar Raggio-de-Sole when grown in sand + soil + vermicompost (1:1:1) (v/v) + inorganic fertilizers + biofertilizers @ 2 g/plant (*Azospirillum* and PSB) produced maximum plant height (73.20 cm), maximum number of flowers (6.06), length of flower stem (68.70 cm), flower size (7.30 cm), earliness in flowering (130.80 day), maximum percentage of A grade flowers (97.33) and vase life (11.00 days) in naturally ventilated polyhouse conditions. Bhatia and Gupta [24] noted that the application of biofertilizers resulted in the greatest flower diameter (7.09 cm) and number of flowers/m2 (180.0) and in the lowest number of days to initial flowering (112.80) in carnation (*Dianthus caryophyllus* Linn.).

China aster

Kumar *et al.* [25] reported the effect of VAM and phosphobacteria on China aster (*Callistephus chinensis*) and reported that application of 3/4 th of the recommended dose of N and P in combination with full K + VAM + phosphobacteria proved to be the most effective in increasing plant height, number of leaves, leaf area, number of branches, flower weight, flower diameter, number of flowers and flower yield. Prabhatkumar *et al*. [26] reported that there was increase in vegetative growth by use of biofertilizers in china aster. Nair *et al*. [27] studied for effect of *Azotobacter* on growth of china aster cv. Local Pink at Akola. Maximum values for the plant growth parameters (plant height, stem girth and branches number per plant) were obtained under soil application of *Azotobacter* + 75% of recommended N rate.

Chrysanthemum

Meshram *et al*. [28] showed that yield attributes like no. of flowers/plant and yield of flowers/ha were significantly maximum with the treatments receiving 80 % NPK + *Azotobacter* + *Azospirillum* + PSB at 5 kg/ha each in annual chrysanthemum cv. Local. Panchal *et al*. [29] found that in annual white chrysanthemum, application of 175 kg N/ha + *Azosprillium* + *Azotobactor* (5 ml per lit, seedling dipping method) produced significantly maximum plant height (96.23 cm), no. of branches per plant (50.59), plant spread (78.08 cm NS and 78.79 cm EW), relative growth rate, leaf area index (21.32 cm2) and harvest index (4.32 %) under middle Gujarat agro climatic condition. Pandey *et al*. [30] noted that the application of 75 % recommended dose of fertilizer and vermicompost coupled with dual inoculation of *Azotobacter* and VAM produced significantly advancement in visible bud formation, tall plant, higher number of lateral shoots, greater plant spread, bud showing colour and flowering, respectively in chrysanthemum.

Verma *et al*. [31] concluded that the treatment receiving *Azospirillum*, Phosphate Solubilising Bacteria (PSB), vermicompost and 50 % recommended NPK recorded signiificantly highest plant height (63.39 cm), number of branches (primary 20.08 and secondary 23.13), plant spread (33.20 cm), dry matter accumulation (42.55 g/plant) in chrysanthemum. Palagani *et al*. [32] found that the treatment receiving 75 % N + 75 % P + 100 % K + VC @ 0.875 t/ha + *Azotobacter* @ 2 kg/ha + PSB @ 2 kg/ha recorded significantly highest plant height (78.00 cm), plant spread (N-S 38.20 cm and E-W 30.86 cm), number of branches (32.66), number of suckers per plant (22.86), fresh weight and dry weight accumulation (318.86 and 37.27 respectively), flowering parameters like early flower bud initiation (52.73 days), first flower opening (72.66 days), 50 percent flowering (91.32 days) and longest flowering duration (54.93 days), yield attributes such as number of flowers per plant (71.47), flower weigh per plant (152.33 g) and flower yield per hectare (13.50 tonne), quality parameters like stalk length (14.56 cm), shelf life of loose flowers (5.00 days), vase life of cut flowers (9.33 days) and *in situ* longevity (12.20 days).

Crossandra

Bhavanisankar and Vanangamudi [33] noted that in crossandra combined application of 100% nitrogen as urea + *Azospirillum* along with 75 % recommended phosphorus as super phosphate + Phosphobacteria gave the highest flower yield per plant. Narasimha and Haripriya [34] revealed that the application of 100 % NPK (75:50:125 kg/ha) + *Azospirillum* + Phosphobacteria each at 2 kg/ha gave the maximum plant height (57.42 cm), no. of branches (12.47), minimum no. of days to first flowering (56.17), maximum sprouts per plant (39.12), length of spike (10.26 cm), no. of flowers per spike (31.01), flower yield (41.72 g/plant) and self life (46.12 hr) in crossandra cv. Dindigul Local.

Dahlia

Sheergojri *et al.* [35] concluded that the application of 75 kg N/ha + 100 kg P/ha + *Azotobacter* gave maximum plant height (77.98 cm), number of primary branches plant-1 (10.53), length of primary branches (58.55 cm), leaf area (88.33 cm2) in Dahlia (*Dahlia variabilis* Desf.) cv. 'Pink Attraction'.

Gaillardia

Rathod *et al.* [36] found that the application of 75 per cent of the recommended NPK rate in combination with *Azospirillum* + *PSB* resulted in highest number of branches (41), leaves (218.67), number of flowers (70.23), flower diameter (5.03 cm), stalk length (7.37 cm), weight of single flower (2.03 g), yield per plant and per hectare (142.57 g and 89.11 q, respectively) in gaillardia. Deshmukh *et al*. [37] revealed that flowering parameters viz. 50 % flowering, diameter of flower and length of flower stalks were increased significantly with an application of 75 % NPK + seedling inoculated with *Azotobacter* + PSB (500 g each 5 liter water) in gaillardia.

Gerbera

Lele *et al*. [38] observed that the inoculation of all the strains of *Azotobacter* in gerbera exhibited beneficial effect by improving the growth parameter very significantly through by increasing the efficiency of N-fixation.

Gladiolus

Karthiresan and Venkateshag [39] reported in gladiolus that combined application of *Azospirillum* and VAM along with recommended dose and 25% reduced dose of NPK recorded maximum plant height

(115.91 cm), increased spike length (103.71 cm) and gave early flowering (48.67 days). Godse *et al.* [40] found that plants receiving vermicompost 8 t/ha + *Azotobacter* and PSB @ 25 kg/ha each + 80 % RDF significantly increased in plant height and leaf number, no. of spikes per ha, no. of corms per plant, weight of corms per ha, length of spike, no. of florets per spike, no. of corms per plant and weight of corms per ha when compared with RDF and other treatments. Dongardive *et al*. [41] reported that NPK resulted in the lowest number of days to corm sprouting (8.91), greatest plant height (85.22 cm), leaf length (69.92 cm), no. of leaves per plant (6.84) and spike length (95.57 cm), number of spikes per plant (1.41), number of florets per spike (13.92) and floret diameter (8.78 cm), followed by vermicompost + *Azotobacter* + PSB (71.69, 90.10 cm, 40.96, 12.87 and 7.91 cm, respectively) in gladiolus cv. White Prosperity.

Pansuriya *et al.* [42] concluded that the application of FYM @ 20 t/ha+ *Azotobacter*. @ 4 kg/ha + PSB @ 4 kg/ha recorded maximum plant height (91.88 cm), number of stem per plant (2.20), fresh and dry weight of plant (208.35 gm and 65.69 gm, respectively) and minimum days to first spike emergence (72.10 days) in gladiolus cv. Psittacinus hybrid. Kaushik *et al.* [43] reported the interaction effect of GA3 @ 200 ppm at 30 DAP + soil treatment with PSB (0.11 g/m2) and were found significantly maximum in respect to number of leaves per plant (8.20), plant height (57.11 cm), width of leaf (1.54 cm), number of florets (20.01), length of spike (72.32 cm), rachis length (28.97 cm) and diameter of the florets (14.90 cm). Also the same treatment gave significantly earlier results in number of days 50 % corms sprouting (8.22 days), days for appearance of initial spike (59.74 days) and days for opening of first floret (77.32 days).

Jasmine

Bhavanisankar and Vanangamudi [44] summarized that the combined application of 75 % recommended nitrogen as neem cake blended urea + *Azospirillum* and 75 % phosphorus as super phosphate + Phosphobacteria gave the highest flower yield in gundumalli. Anburanni and Kavitha [45] reported that in mullai (*Jasminum auriculatum*) treatment received FYM + 125 % NPK (150:300:300 g/plant) + *Azospirillum* and Phosphobacteria @ 2 kg/ha gives highest plant height (167.67 cm), length of primary shoot (157.02 cm), no. of secondary shoots (9.99), no. of productive shoots (211.3), leaf area per plant (82.31 cm), plant spread (2.27 m2), maximum no. of flowers per plant, hundred bud weight (7.74 g) and flower yield (8392.97 kg/ha).

Marigold

Mathew and Singh [46] reported that a combined application of PSB, *Azotobacter* and *Azospirillum* produced plant with maximum plant height, number of branches, flower size and yield when compared with single application of those biofertilizers and uninoculated plants (control) of African marigold cultivar ‘Pusa Narangi Gainda’. Syamal *et al.* [47] found that the application of *Azotobacter* (A) and phosphobacteria (P), each at 1.00 and 1.50 kg/ha, produced maximum plant height (61.77 cm) was recorded with A at 1.50 kg/ha, followed by A at 1.00 kg/ha (61.33 cm). The highest number of leaves per plant (240.88) was recorded with P at 1.00 kg/ha, followed by P at 1.50 kg/ha (221.77). The maximum fresh and dry weights of leaves were recorded with A at 1.00 kg/ha (13.54 and 2.55 g), followed by A at 1.50 kg/ha (12.76 and 2.34 g) in marigold (*Tagetes erecta*) cv. Rusty Red. Bhaskaran *et al*. [48] studied the effect of *Azotobacter* and *Azospirillium* biofertilizers in marigold (*Tagetes erecta* L.) under the different levels of chemical nitrogen. Both bacterial inoculants responded to all levels of chemical nitrogen with an increase in yield as compared to corresponding control.

Radhika *et al*. [49] found that the application of 70 % RDF + 3 t/ha vermicompost + *Azotobacter* + *Azosprillium* + PSB produced significantly maximum plant height (115.27 cm), No. of branches per plant (26.63) and plant spread in N-S and E-W direction (83.73 and 82.00 cm, respectively), maximum average flower weight (7.43 g), No. of flowers per plant (52.37), flower yield per plant (388.33 g) and flower yield per ha (14.38 t) as compared to control in African marigold (*Tagetes erecta* L.) cv. Local. Thumar *et al.* [50] reported that the maximum diameter of flower (7.30 cm) was recorded with treatment 70 % RDF + 2 t/ha vermicompost + *Azotobacter* + *Azospirillium* + PSB. The longest duration of flowering (61.14 days), was recorded in 70 % RDF + 2 t/ha vermicompost + *Azospirillium* + PSB. The treatment 70 % RDF + 2 t/ha vermicompost + *Azotobacter* + *Azospirillium* + PSB significantly gave higher yield parameters viz., flower yield per plant (376.57) and flower yield per hectare (185.65 q ha-1) in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda.

Sharma *et al*. [51] concluded that the application of *Azospirillum* + Phosphate-Solubilizing Bacteria + 5 % cow urine + 50 % recommended dose of ‘N’ through vermicompost + 50 % recommended dose of NPK fertilizer was most effective in increasing vegetative growth parameters, such as plant height (53.31 cm), plant spread (37.78 cm) as well as flower yield parameters like number of flowers per plant (32.80), flower diameter (6.18 cm), flower yield (3.18 kg/plot and 22.09 t/ha), flowering duration (76.16 days), shelf life (7.89 days) and it also had the maximum benefit: cost (B:C) ratio (3.56) in African marigold cultivar ‘Pusa Narangi Gainda’.

Rose

Singh *et al.* [52] studied the response of manures and biofertilizers on growth and flowering in rose and recorded that application of poultry manure (4 kg/m2) + NPK 25:20:15 g/m2 + *Azotobacter* gave the highest fresh weight of leaf (0.268g). Singh (2007) found that application of 4 kg FYM/m2 + 50 % RDF + *Azotobacter* in rose gave maximum no. of flowers per plant (24.50), weight of flower per plant (128.40 g), flower diameter (9.06 cm), no. of petals per flower (43.83) and yield of flower/m2 (1472.53 g). Bhor [53] reported that the treatment 160:150:300 kg NPK/ha + VAM @ 2 kg/ha + *Azotobacter* @ 2 kg/ha + *Azospirillum* @ 1 lit./ha recorded significantly maximum diameter of bud (19.06 mm), bud length (31.75 mm), diameter of flower (9.61 cm), vase life (8.09 days), number of flower per plant (13.05), number of flowers per ha (5.43 lakh) in rose cv. Shakira.

Statice

Gayithri *et al*. [54] observed that the flower components in statice like highest plant height, number of leaves, number of branches spike emergence, initiation of flower, flower harvesting, spike length, spread and no. of branches/spike were favorably influenced by the application of 50 % NP + 100 % K + VC + *Azotobacter* + PSB. The same treatment showed highest flower yield (4.93 spikes / plant).

Tuberose

Wange and Patil [55] conducted a pot trial on tuberose cv. Single and found that application of 100 kg N /ha with or without inoculating with *Azotobacter* + *Azospirillum* mixtures significantly increased the number of flowers per stalk, bulb (rhizome) yield and the number of flower stems. Swaminathan *et al.* [56] found the highest fresh weight with application of 120 : 25 : 65 kg NPK/ha + Phosphorus solublizing bacteria. Further, treatment of 120 : 65 : 62.5 kg NPK/ha + *Azospirillum* + *PSB* resulted in highest spike length, number of flowers per spike, flower weight, number of tubers, tuber weight per plant and yield per hectare (3.08 and 2.75 t/ha for the Ist and IInd year, respectively) in 'Maxican Single' cultivar of tuberose. Chopde *et al.* [57] investigated that the flower quality and yield contribute characters of tuberose, i.e. length and diameter of spike, length of rachis, no. of florets per spike, no. of spikes per plant and yield of florets per hectare, were significantly increased with the application of vermicompost (2 t/ha) + *Azotobacter* + PSB (each at 2.5 g/m^2) compared to other treatments. Chaudhary [58] concluded that the lowest time taken for spike emergence (84 day), basal florets opening (101 day), maximum spike length (89 cm), no. of florets per spike (49.2), and no. of bulbs produced per plant (19.13) were noted with an application of *Azotobacter* + PSB + VAM in tuberose cv. Double.

Shankar *et al*. [59] investigated that the tuberose cv. Single, when grown with vermicompost and PSB @ 1 kg/m^2 and 2 g/bulb, respectively, produced highest spike length (77.70 and 77.86 cm, respectively), maximum number of spikes per plant (1.49 and 1.49, respectively), weight of bulbs per plant, i.e. clump weight (283.58 and 295.90 g, respectively) and longevity of spikes (15.69 and 15.80 days, respectively) in first and second year. Hadwani *et al.* [60] showed the significant result and application of FYM @ 30 t/ha + PSB @ 2 g/m^2 + *Azotobacter* @ 2 g/m^2 (T13) took minimum days to sprouting (18.47 days), maximum plant height (61.67 cm) and plant spread at E-W and N-S (37.93 cm and 37.07 cm, respectively). With respect to flowering, significantly maximum length of spike (78.00 cm), number of florets per spike (44.07), number of spikes per plant (4.26), number of spikes per net plot (127.67), number of spikes per hectare (4.73 lacks), longest vase life (12.33 days) and *in situ* longevity of spike (20.80 days) were recorded in treatment ½ RDF + NC @ 1 t/ha + PSB @ 1 g/m^2 + *Azotobacter* @ 1 g/m^2.

Tulip

Khan *et al.* [61] reported that inoculation of *Azotobacter* significantly increased the plant height (38.90 cm), wrapper leaf area (lower most leaf) (143.39 cm^2), tepal diameter and bulb yield in tulip (*Tulipa gesneriana*).

CONCLUSION

This study spectacle that bio-inoculants produce growth promoting substances which surge nutrients availability in plants ultimately increase the yield of crop plants. Use of bio-fertilizers can minimize or utterly eliminate the use of synthetic fertilizers, decreasing environmental hazards, improve soil structure and increase productivity of flowers. Bio-fertilizers are cheaper and significant in affecting the yield in cereal crops. Research exertions are required for exploring new and better horticultural effectiveness of bio-fertilizers in flowers crops.

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CITATION OF THIS ARTICLE
Gawade Nagesh Vithu, Varu D. K., Dishaben Patel, Aghera Sameer R. Efficacy of Biofertilizers to improve Flower Production: A review. Bull. Env. Pharmacol. Life Sci., Vol 8 [1] December 2018 : 09-17