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Effect of Integrated Nutrient Management on Growth and Production of Hydrangea (*Hydrangea macrophylla* Thunb.)

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ABSTRACT

A field experiment was carried out to assess the effect of integrated nutrient management on growth and production of hydrangea at experimental farm of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, during the year 2017. Findings revealed that vegetative parameters like plant height (137.67 cm), stem length (55.18 cm), number of shoots per plant (21.59), number of leaves per plant (248.52) and yield parameters like number of cut flowers per plant (36.21) and yield of cut flowers per square meter (172.80) were found maximum in treatment T_4 (*Azotobacter* + PSB + 70% RDF). Also, flowering parameters like minimum number of days taken for flower bud formation (93.68 days), minimum number of days taken from flower bud formation to harvesting stage (38.06 days) and maximum duration of flowering (51.36 days) were observed form the same treatment T_4 (*Azotobacter* + PSB + 70% RDF). However, maximum stem thickness (12.26 mm) and quality parameters like inflorescence diameter (27.53 cm), weight of cut flower stem (87.34g) and vase life (19.50 days) were found maximum in treatment T_3 (*Azotobacter* + PSB + 80% RDF).

Introduction

Hydrangea (*Hydrangea macrophylla* Thunb.) belongs to family Hydrangeaceae and it is native to humid forest of Japan. It is a hardy flowering shrub and very suitable for growing particularly in the cool and moist regions (Juhanoja *et al.*, 1998). The inflorescence (cymose) is composed of sterile flowers with white enlarge sepals as well as inconspicuous fertile flowers, which are buried beneath the sterile flowers. Hydrangea has become an important cut flower, pot and garden plant in hilly areas. In India, places having cool climates like Kashmir, Himachal Pradesh, Nainital, Kalimpong, Darjeeling, southern and northern hills, Shillong, etc. has the potential for growing good quality hydrangeas as cut flowers or container plants (Bhattacharjee, 2006).

Increased flower production, quality of flowers and perfection in plant forms are the important objectives to be reckoned in commercial flower production. Though the quality of flowers is primarily a varietal trait, it is greatly influenced by climatic, geographical and nutritional factors among which nutrition plays a major role. In India, a very little research has been done on nutrition of hydrangea. Growers are applying chemical fertilizers following hit and trial methods, thereby resulting in poor health besides atmospheric pollution, and ultimately resulting in nutrient imbalance and poor fertilizer use efficiency. Further, chemical fertilizers are costly, short in supply and are derived from non-renewable sources of energy. It is therefore necessary to restrict the use of chemical fertilizers to a certain limit which can be achieved through the use other nutrient sources along with it. To minimize the use of these inputs without affecting the overall production and the ecosystem, it is necessary to use ecofriendly, economical and easily available biofertilizers for ensuring quality, maintaining soil fertility and for the development of more efficient fertility management programme. Hence, there is a need to develop sustainable production system, wherein chemical fertilizers can be minimized by using alternative sources of nutrients. Integrated nutrient management (INM) practices involving judicious combination of bio-fertilizers and chemical fertilizers can be feasible and viable means for production of hydrangea on a commercial and profitable scale. Keeping the above facts in view, the present investigation has been planned to study the effect of integrated nutrient management for commercial flower production of hydrangea.

Materials and Methods

Field experiment was carried out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the year 2017. The experimental site is located at an elevation of 1276 m above mean sea level lying between 32^o 51’0’’ North latitude and 77^{o}11’30’’ East longitude. The climate is sub-temperate with annual rainfall ranges between 800-1300 mm. The soil of the experimental field was sandy loam with 6.96 pH, high in organic carbon (1.08 %), medium in available nitrogen (514.3 kg/ha), high in available phosphorous (526.4 kg/ha) and potassium (722.4 kg/ha). The experiment was laid out in a randomized block design with ten treatments and three replications. The recommended dose of fertilizer (RDF) for the production of hydrangea is 80g N/m^2 and 50 g K/m^2 (Thaneshwari, 2014). For the present study, nutritional treatments comprised of T_1 (100% RDF), T_2 (*Azotoabacter* + PSB + 90% RDF), T_3 (*Azotobacter* + PSB +80% RDF), T_4 (*Azotobacter* + PSB +70% RDF), T_5 (*Azotobacter* + AM + 90% RDF), T_6 (*Azotobacter* + AM + 80% RDF), T_7 (*Azotobacter* + AM + 70% RDF), T_8 (PGPR + 90% RDF), T_9 (PGPR + 80% RDF) and T_{10} (PGPR + 70% RDF). Application of fertilizers was started when buds were sprouted from the main stem. Biofertilizers were applied one week after application of chemical fertilizers through soil application method. *Azotobacter* and PSB @ 2g/plant, AM @ 5g/plant and PGPR @ 5ml/plant were mixed properly with finely sieved soil and incorporated around the root zone of each plant according to treatment combinations. The observations on various growth and flowering characters were recorded. A perusal of data (Tables 1, 2 and 3) revealed that all the growth, flowering, yield and quality parameters of hydrangea were significantly affected by different treatments.

Results and Discussion

Effect of Integrated Nutrient Management (INM) on growth parameters in Hydrangea

The data presented in Table 1 shows vegetative growth as affected by the integrated application of different doses of chemical fertilizers and different biofertilizers. The treatment of plants with chemical and biofertilizers significantly increased the plant height, stem length, number of shoots per plant, stem thickness and number of leaves per plant in comparison to control. Results clearly showed that the combined application of *Azotobacter* and PSB along with 70% recommended dose of chemical fertilizers proved to be beneficial for robust growth of plant as compared to other treatments.

The maximum plant height (137.67 cm), stem length (55.18 cm), number of shoots per plant (21.59) and number of leaves per plant (248.52) were recorded in treatment T_4 (*Azotobacter* + PSB + 70% RDF) whereas, the maximum stem thickness (12.26 mm) was observed treatment T_3 (*Azotobacter* + PSB + 80% RDF).

However, minimum plant height (115.21 cm), stem length (30.63 cm), number of shoots per plant (13.65), stem thickness (7.31 mm) and number of leaves per plant (198.39) were recorded in T_1 (control). The increased plant growth in treatment T_4 might be due to chemical fertilization in combination of biofertilizers (*Azotobacter* and PSB) proved to be beneficial to fix the atmospheric nitrogen and solubilize fixed phosphorus in soil. This can also be attributed to the production of plant growth promoting substances like auxins, gibberellins and other organic acids in the vicinity of roots by the biofertilizers which stimulated the plant metabolic activities and photosynthetic efficacy leading better growth and development of plant (Kumar *et al.*, 2016). Rao *et al.*, (1985) documented that inoculation with more than one microorganism benefits crops by enhancing the synergistic action of the associates in growth and nutrient uptake.

Also, increased cell elongation and cell multiplication due to enhanced nutrient uptake by plants following inoculation of *Azotobacter* and PSB probably caused the increased growth parameters. The result of the present study is in close conformity with the findings of Neelima *et al.*, (2013) and Patanwar *et al.*, (2014) in chrysanthemum. Also, Singh *et al.*, (2015) recorded significant improvement in growth parameters like plant height, plant spread, leaf area and number of branches in marigold due to application of *Azotobacter* with recommended doses of nitrogen, phosphorus, potash.

Table.1 Effect of Integrated Nutrient Management (INM) on growth parameters in hydrangea (*Hydrangea macrophylla* Thunb.)

Treatments	Plant height (cm)	Stem length (cm)	Number of shoots per plant	Stem thickness (mm)	Number of leaves per plant
T_1	115.21	30.63	13.65	7.31	198.39
T_2	127.90	44.11	17.07	10.42	227.56
T_3	132.95	49.50	19.81	12.26	238.73
T_4	137.67	55.18	21.59	11.98	248.52
T_5	125.72	41.60	16.34	9.96	222.33
T_6	129.18	46.13	18.51	11.99	233.78
T_7	135.22	52.67	20.46	11.09	243.28
T_8	117.41	33.33	13.96	7.84	207.41
T_9	122.91	38.67	15.26	9.29	214.97
T_{10}	120.16	36.33	14.76	8.58	211.52
$CD_{0.05}$	2.99	2.84	0.73	0.29	5.30

Table.2 Effect of Integrated Nutrient Management (INM) on flowering parameters in hydrangea (*Hydrangea macrophylla* Thunb.)

Treatments	Number of days taken for flower bud formation	Number of days taken from bud formation to harvesting stage	Duration of flowering (days)
T_1	105.65	43.02	39.32
T_2	98.16	40.39	45.49
T_3	95.59	39.42	48.59
T_4	93.68	38.06	51.35
T_5	99.47	40.52	43.77
T_6	96.61	39.63	46.61
T_7	94.75	38.39	49.75
T_8	104.61	42.84	39.94
T_9	100.70	41.07	42.36
T_{10}	101.54	41.90	40.54
$CD_{0.05}$	1.60	0.54	2.09

Table.3 Effect of Integrated Nutrient Management (INM) on yield and quality parameters in hydrangea (*Hydrangea macrophylla* Thunb.)

Treatments	Number of cut flowers per plant	Yield of cut flowers per meter square	Weight of cut flower stem (g)	Inflorescence diameter (cm)	Vase life (days)
T_1	22.71	105.33	59.36	22.70	14.53
T_2	28.57	136.00	77.39	29.05	17.49
T_3	32.90	158.00	87.34	27.53	19.50
T_4	36.21	172.80	86.44	26.34	18.30
T_5	27.66	130.40	73.35	25.69	16.49
T_6	31.11	148.13	86.73	26.80	18.73
T_7	34.33	162.67	80.48	28.31	17.65
T_8	23.55	118.67	62.82	23.02	15.28
T_9	25.76	122.00	69.79	24.63	16.31
T_{10}	24.82	111.87	66.55	24.15	15.78
$CD_{0.05}$	2.88	3.38	1.00	1.57	1.44

Similarly, Mittal *et al.*, (2010) observed improved growth characters with the application of biofertilizers in marigold. The significant variations in growth parameters due to application of chemical and biofertilizers clearly indicate that the integrated nutrient management may be beneficial for crop improvement.

Effect of Integrated Nutrient Management (INM) on flowering parameters in Hydrangea

Data presented in Table 2 on flowering parameters showed significant response to different treatments of integrated nutrient management with respect to days taken for flower bud formation, number of days taken from flower bud formation to harvesting stage and duration of flowering.

The plants receiving *Azotobacter* + PSB + 70% RDF (T_4) in combination had taken minimum number of days taken for flower bud formation (93.68 days), minimum number of days taken from flower bud formation to harvesting stage (38.06 days) and maximum duration of flowering (51.36 days) in comparison to other treatments. However, maximum number of days taken for flower bud formation (105.65 days), maximum number of days taken from flower bud formation to harvesting stage (43.02 days) and minimum duration of flowering (39.32 days) were observed in T_1 (control).

The earliness in flowering in treatment T_4 may be attributed to inoculation of *Azotobacter* and PSB which might have led to easy uptake of nutrients and simultaneous transport of growth promoting substance like cytokinins to auxillary buds resulting in breakage of apical dominance. Ultimately, they resulted in better sink for faster mobilization of photosynthates, early completion of vegetative growth and changing of vegetative primordia to reproductive primordia. Similar significant effects on flowering parameters with the application of chemical fertilizers coupled with biofertilizers were observed by Dalawai *et al.,* (2014) in carnation and Pandey *et al.,* (2010) in chrysanthemum.

Improvement in flowering duration might be due to improved soil health, high water retention capacity and availability of microbes (Singh *et al.,* 2015). Also, Neelima *et al.,* (2013) observed flowering parameters like early bud initiation, first flower opening, 50 per cent flowering and longest flowering duration with the application of biofertilizers in marigold.

Effect of Integrated Nutrient Management (INM) on yield and quality parameters

Significantly, yield parameters like maximum number of cut flowers per plant (36.21) and yield of cut flowers per meter square (172.80) were also observed from the same treatment containing *Azotobacter* + PSB + 70% RDF (T_4). While, minimum number of cut flowers per plant (22.71) and yield of cut flowers per meter square (105.33) were recorded in control (T_1). The possible reason for better yield in treatment T_4 could be that *Azotobacter* might have created favourable conditions for atmospheric nitrogen fixation and phosphorous solubilization by PSB at higher rate and thus making nutrients and water available to the plants. This in turn increases photosynthesis which enhances food accumulation. The diversion of photosynthates towards sink might have resulted in better growth and subsequently higher number of flowers per plant and higher flower yield of cut flowers per metre square (Verma *et al.,* 2011). Similarly, Laishram *et al.,* (2013) in chrysanthemum also reported higher flower yield with the inoculation of biofertilizers.

However, quality parameters like inflorescence diameter (27.53 cm), weight of cut flower stem (87.34g) and vase life (19.50 days) were found maximum in treatment T_3 (*Azotobacter* + PSB + 80% RDF). However, minimum inflorescence diameter (22.70 cm), weight of cut flower stem (59.36 g) and vase life (14.53 days) were observed in T_1 (control). The improved quality in treatment T_4 may be attributed to better source and sink relationship in addition to excellent physiological and biochemical activities due to inoculation of biofertilizers which lead to sufficient supply of micro and macronutrients resulting in plants with healthy growth. Also, biofertilizers enhance the level of auxins which divert the photo assimilates to the developing flower buds, resulting in increased petal number thereby, increasing inflorescence diameter and weight of cut flower. Similar result of increased flower diameter in biofertilizers inoculated plants was observed by Dalawai and Naik (2014) in carnation and Kirar *et al.,* (2014) in China aster who reported maximum length and width and fresh weight of floral heads with the application of 50% NPK + Vermicompost + *Azotobactor* + PSB. Hadwani *et al.,* (2013) observed maximum vase life in tuberose with the application of PSB, *Azotobacter* along with neem cake and recommended dose of fertilizers.

Also, Bosali *et al.,* (2014) found maximum vase life in gladiolus with the application of 3/4th N, P and K+ PSB + KSB. Application of biofertilizers influenced flower longevity due to the increased nutrient uptake by plant and greater development of water conducting tissues, resulting in more uptake of water in vase. It might also be due to the presence of ethylene inhibitors or due to presence of cytokines which delay senescence of florets. These findings are in conformity with those of (Karthiresan *et al.,* 2002) in gladiolus and (Gayithri *et al.,* 2004) in static.

From the above discussion, it is concluded that the best integrated nutrient management schedule for growth and flower production of hydrangea is *Azotobacter* + PSB + 70% RD as it resulted in improvement for most of the parameter of economic importance.

Vegetative characters like plant height, stem length, number of shoots per plant, number of leaves per plant and flowering characters like number of cut flowers per plant and yield of cut flowers per square meter were found maximum in T_4 (*Azotobacter* + PSB + 70% RD). And also this treatment showed minimum number of days taken for flower bud formation, minimum number of days taken from flower bud formation to harvesting stage and maximum duration of flowering (days).However, stem thickness, inflorescence diameter, weight of cut flower stem and vase life were found maximum in treatment T_3 (*Azotobacter* + PSB + 80% RDF) but it was found statistically at par with the T_4 (*Azotobacter* + PSB + 70% RDF).

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