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Response of globe amaranth (*Gomphrena globosa* L.) to pinching and biofertilizer application

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Abstract
The present study on Response of Globe amaranth (*Gomphrena globosa* L.) to pinching and biofertilizer application was conducted at SKUAST-K, Shalimar Campus, J&K during the year 2018. The experiment was laid out in Split Plot Design with three replications. Pinching as main plot treatment comprising two levels P_0 (No pinching) and P_1 (Pinching) along with biofertlizers as sub-plot treatment comprising of eight different levels B_0 (No biofertilizer), B_1 (*Azotobacter*), B_2 (Phosphate solubilising bacteria), B_3 (Potassium solubilising bacteria), B_4 (*Azotobacter* + PSB), B_5 (*Azotobacter* + KSB), B_6 (PSB + KSB) and B_7 (*Azotobacter* + PSB + KSB) with a total of 16 treatment combinations. The results of the study revealed that P_1 (Pinching) recorded maximum plant spread (50.36 cm), number of leaves plant^{-1} (309.49), LAI (6.83), primary and secondary branches plant^{-1} (3.58 and 11.08 respectively), stem diameter (1.93 cm), number of flowers plant^{-1} (116.14), whereas maximum plant height (68.23 cm) at harvest, individual leaf area (27.08 cm^2), minimum days taken to flower bud appearance and 50% flowering (29.62 and 43.21 days), respectively was recorded under P_0 (No Pinching). Among different biofertilizers B_7 (*Azotobacter* + PSB + KSB) recorded maximum plant height (65.04 cm) at harvest, plant spread (52.19 cm), number of leaves plant^{-1}(304.81), individual leaf area (28.44 cm^2), LAI (7.77), primary and secondary branches plant^{-1} (3.42 and 11.72), stem diameter (1.93 cm), minimum days taken to flower bud appearance and 50% flowering (32.54 and 46.31 days) and number of flowers plant^{-1} (122.21). Interaction effect of pinching and biofertilizers was found beneficial in improving vegetative characters and flower yield.

Keywords: pinching, globe amaranth, biofertilizers, interaction effect, vegetative growth, flowering, yield

Introduction
The Globe amaranth (*Gomphrena globosa* L.) commonly known as Bachelor's button is widely used as loose and dry flower besides for beds, borders, pots and rock gardens. In Kashmir valley its commonly called as Mahraz posh or Gundi. The dried flowers are used in floral arrangements, indoor decoration and for value added products. *Gomphrena globosa* L. is native to Central America including regions of Brazil, Panama and Guatemala. Genus gomphrena belongs to the family Amaranthaceae and consists of about 100 species of half-hardy annual, biennial and herbaceous perennial, but only one species *Gomphrena globosa* L. with its cultivars is in general cultivation. The plant fixes carbon through the C_4 pathway. The edible plant *Gomphrena globosa* L. has been used in herbal medicine. The flowers are rich in antioxidants and used in folk remedy, flowers are boiled to make tea which is used for baby gripe, cough and diabetes. This remedy is also used for several respiratory inflammation conditions including bronchial asthma, acute and chronic bronchitis, and whooping cough. The flowers are also rich in betacyanins which have a wide range of applications as additives and supplements in the food industry, cosmetics, and livestock feed. Apical dominance is a phenomenon in which main stem is dominant over lateral. The apical bud produces auxin (IAA) that inhibits the growth of lateral buds, thus height of the plant increases producing less number of branches. However, if apical portion of shoot is removed early, large number of axillary shoots arises resulting in well-shaped bushy plant bearing more number of uniform flowers. Pinching is the removal of shoot tip along with two to three opened leaves. Most of the Indian soils lack proper balance of nutrients present in available form for plant uptake. Inorganic or chemical fertilizers besides being short in supply and costly also deteriorate soil health, ground water and environment. Nowadays, lot of emphasis is being given on the use of bio-fertilizers, as it is not only low cost input but also gives high returns and is eco-friendly.

Bio-fertilizers usually consist of preparations containing live or latent cells of efficient strains of micro-organisms which include biological nitrogen fixers, Phosphorous and Potash solubilisers/ mobilisers. Use of bio-fertilizers reduces per unit consumption of inorganic fertilizers and increases the quality and quantity of flowers (Syamal *et al.* 2006). Thus the standard horticultural practices eg; Pinching along with the application of biofertilizers can play important role in enhancing vegetative growth, flowering and seed yield in Globe amaranth.

Material and Methods

The present investigation was conducted at Experimental farm of Division of Floriculture and Landscape Architecture in main campus of Sher-e-Kashmir University of Agriculture Sciences and Technology of Kashmir, Shalimar, Srinagar, which is situated 16 km away from city centre that lies between 34^0 05′ N latitude and 74^0 98′ E longitude at an altitude of 1587 meters above mean sea level. The climate is temperate-cum-Mediterranean and continental type characterized by hot summer and severe winters. The average annual precipitation is 944.6 mm (average over past thirty years) and more than 80% of precipitation is received from western disturbances. The experiment consisted of main plot treatment *viz* Pinching having 02 levels, P_0 (No pinching) and P_1 (Pinching); and sub-plot treatment *viz* Biofertilizers having 08 levels, B_0 (No biofertilizer), B_1 (*Azotobacter*), B_2 (Phosphate solubilising bacteria) B_3 (Potassium solubilising bacteria), B_4 (*Azotobacter* + PSB), B_5 (*Azotobacter* + KSB), B_6 (PSB+KSB) and B_7 (*Azotobacter* + PSB + KSB) with a total of 16 treatment combinations (T_1= P_0B_0, T_2 = P_0B_1, T_3= P_0B_2, T_4 = P_0B_3, T_5= P_0B_4, T_6 = P_0B_5, T_7 = P_0B_6, T_8 = P_0B_7, T_9 = P_1B_0, T_{10} = P_1B_1, T_{11}= P_1B_2, T_{12} = P_1B_3, T_{13} = P_1B_4, T_{14} = P_1B_5, T_{15} = P_1B_6, T_{16} = P_1B_7) replicated three times in Split Plot Design. All cultural operations were uniformly followed as per the standard practices. Biofertilizer application was done through dipping root portion of seedlings in solution prepared by mixing biofertilizers in 1000 ml of water for 30 minutes before transplanting. Biofertilizers *viz Azotobacter*, PSB and KSB were procured from SKUAST-K Wadura, Sopore. The healthy, disease free seedlings of uniform size and vigour at 5-6 leaf stage were selected and transplanted during evening time in beds with row to row and plant to plant spacing of 30 × 40 cm accommodating 9 plants/m^2. Pinching was carried out 20 days after transplanting. Five plants were randomly selected from each unit plot for collecting data.In the current study data on plant height, plant spread, number of leaves plant^{-1}, leaf area, LAI, number of primary and secondary branches plant^{-1}, days taken to flower bud appearance and 50% flowering and number of flowers plant^{-1} are reported.

Results and Discussion

Effect on growth characters

In the present investigation, data recorded on growth parameters presented in Table 1 revealed plant height was significantly influenced by pinching. Maximum plant height at harvest (68.23 cm) was recorded with P_0 (no pinching) which could be credited to apical dominance, whereas in case of pinching, plants remained significantly dwarf as compared to no pinching. Minimum plant height at harvest (56.33 cm) was recorded with P_1 (Pinching). This might be due to removal of apical portion of plant which resulted in reduction of plant height. Similar results were reported by Nain *et al.* (2017) [4] and Parhi *et al.* (2016) [8].

The perusal of data indicated that P_1 (pinching) recorded maximum number of leaves per plant, LAI, primary and secondary branches per plant (309.49, 6.83, 3.58 and11.08) while unpinched plants recorded minimum growth (269.49, 6.59, 2.51, 8.80), respectively with respect to the above parameters. It is mainly due to the removal of apical portion of the plant which inhibited the apical dominance and diverted plant metabolites from vertical to horizontal growth. The pinching of apical buds lowered concentration of phytohormones (IAA) thus encouraged growth of lateral buds to produce new shoots. Also the translocation of photosynthates to leaf auxiliary buds increased number of leaves per plant. Similar results have also been reported by Prakash *et al.* (2016) [9] and Singh *et al.* (2015) [10]. However maximum individual leaf area (27.08 cm^2) was recorded with P_0 (no pinching) which might be due to availability of more food material and better allocation of energy because of lesser number of leaves. Minimum leaf area (cm^2) in pinching treatment might be attributed to sharing of energy by the developing shoots and leaves. Similar results have also been reported by Ahmad *et al.* (2007) [14].

Maximum plant height at maturity, number of leaves per plant, individual leaf area, LAI, primary and secondary branches per plant (65.04 cm, 304.81, 28.44 cm^2, 7.77, 3.42 and 11.72) was recorded with treatment B_7 (*Azotobacter* + PSB + KSB) which is in conformity with the result of Vaishali *et al.* (2018) [3], Satyanarayana *et al.* (2018) [2] and Kiran *et al.* (2014) [11], whereas minimum growth (59.69 cm, 261.09, 22.49 cm^2,5.28, 2.52 and 7.56) was recorded with treatment B_0 (no biofertilizer), respectively with respect to the above parameters. This might be due to timely supply of required plant nutrients in the form of biofertilizers which resulted in better nutrition and increased photosynthetic activity, enhanced cell division and enlargement. Azotobacter has a direct role in plant vegetative growth and may have been beneficial by fixing atmospheric nitrogen and secreting several growth promoting hormones (auxins, cytokinins and gibberellins etc.) resulting in better plant growth. Also phosphorous caused conversion of photosynthates into phospholipids resulting in enhanced vegetative growth.

P_1 (pinching) recorded maximum plant spread and stem diameter (50.36 cm and 1.93 cm) while as minimum plant spread and stem diameter (49.36 cm and 1.82 cm) was recorded with P_0 (no pinching). This might be due to the fact that pinching reduces the plant height and encourages the growth of side branches attributed to the breaking of apical dominance which might have favored in increasing the stem diameter. In case of no pinched plants height is more as compared to pinched plants but stem diameter is less. These results are in close agreement with the findings of Nain *et al.* (2017) [4], Chauhan *et al.* (2016) [7] and Parhi *et al.* (2016) [8].

Among biofertilizers mean maximum plant spread and stem diameter (52.19 cm, 1.93 cm) was recorded with B_7 (*Azotobacter* + PSB + KSB) while as B_0 (no biofertilizer) treatment recorded minimum plant spread and stem diameter (47.07cm and 1.78 cm). This might be due to increased nitrogen fixation by *Azotobacter*, as nitrogen is an essential part of nucleic acid thus plays vital role in promoting the plant growth and the role of PSB and KSB as they solubilize fixed phosphorous and mobilize potassium in

the soil. Thus availability of nutrients through different biofertilizers and secretion of growth promoting substances stimulated the plant metabolic activities and enhanced photosynthetic efficacy lead to robust growth of the plant. Similar results were obtained by Rolaniya *et al.* (2017) [5] and Yadav *et al.* (2017) [6].

The data recorded on growth parameters presented in Table 2 revealed that various combination of pinching and biofertilizers could not bring any significant change in various growth characters. However, combination of P_1B_7 (pinching + *Azotobacter* + PSB + KSB) resulted in better growth performance as maximum plant spread, stem diameter, number of leaves per plant, LAI, primary and secondary branches per plant (52.72 cm, 1.99 cm, 325.57, 7.89, 3.93, 13.23) whereas minimum growth performance (46.88 cm, 1.77 cm, 250.22, 5.26, 2.00, 7.13) was recorded with P_0B_0 (no pinching + no biofertilizer) with respect to above parameters.

Effect on floral characters

The data recorded on floral parameters presented in Table 1 showed that pinching had significant influence on number of days taken to flower bud appearance and 50 per cent flowering. P_0 (no pinching) recorded minimum days taken to flower bud appearance and 50 per cent flowering (29.62 and 43.21 days), whereas maximum days taken to flower bud appearance (39.37 and 53.29 days) was recorded with P_1 (pinching).

This might be due to the fact that after removal of apical meristem, the plant continued to be in vegetative phase, new and emerging shoots took more days to become physiologically mature and to stimulate buds development which ultimately delayed the flower bud initiation and 50 per cent flowering. These finding were also supported by Jyothi *et al.* (2018) [1] and Parhi *et al.* (2016) [8]. However P_1 (pinching) recorded maximum number of flowers per plant (116.14) while as minimum number of flowers per plant (104.46) was recorded with P_0 (No pinching). Increase in number of flowers per plant with pinching might be attributed to breaking of apical dominance which stimulated branching and diverted plant metabolites from vertical to horizontal growth which lead to proportionate increase in yield-contributing characters and thus more number of flowers per plant. Similar results were also reported by Singh *et al.* (2015) [10].

Among different biofertilizers minimum days taken to flower bud appearance and 50 per cent flowering (32.54 and 46.31 days) was recorded with treatment B_7 (*Azotobacter* + PSB + KSB) followed by treatment B_6 (PSB + KSB) i.e. (33.16 and 47.06 days), whereas maximum days taken to flower bud appearance and 50 per cent flowering (36.46 and 50.72 days) was recorded with B_0 (no biofertilizer) treatment. Also maximum number of flowers plant per plant (122.2) was recorded with this treatment while as minimum number of flowers per plant (91.59) was recorded with B_0 (no biofertilizer) treatment. This might be due to due to proper uptake of nutrients and the secretion of growth promoting substances like auxins, gibberellins, vitamins and other organic acids by the biofertilizers which promoted faster vegetative growth and ultimately flower bud formation took place earlier.

Further, potassium increases the rate of photosynthesis and mobilization of sucrose to the shoots which have positive influence in flower bud initiation and thus on 50 per cent flowering. More number of branches was produced in this treatment which ultimately resulted in increased number of flowers. These results are in close agreement with the findings of Rolaniya *et al.* (2017), Palagani *et al.* (2013) [2] and Sheergojri *et al.* (2013) [13].

The data recorded on floral parameters presented in Table 2 revealed that interaction of pinching and biofertilizers had no significant influence on various floral characters. However, combination of P_1B_7 (pinching + *Azotobacter* + PSB + KSB) resulted in better floral characters and increased number of flowers per plant (128.33) whereas minimum number of flowers per plant (87.85) was recorded with P_0B_0 (no pinching + no biofertilizer).

Fig 1: Biofertilizer treatment to seedlings

Fig 2: Effect of pinching on Globe amaranth

Fig 3: Globe amaranth (*Gomphrena globosa* L.) at full bloom stage

Table 1: Effect of pinching and biofertilizers on growth and flowering in Globe amaranth (*Gomphrena globosa* L.)

Treatment	Plant height (cm)	Plant spread (cm)	Number of leaves plant^{-1}	Leaf area (cm^2)	Leaf area index (LAI)	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Stem diameter (cm)	Days taken to flower bud appearance	Days taken to 50% flowering	Number of flowers plant^{-1}
Main Plot – Pinching											
No pinching (P_0)	68.23	49.36	269.49	27.08	6.59	2.51	8.80	1.82	29.62	43.21	104.46
Pinching (P_1)	56.33	50.36	309.49	24.47	6.83	3.58	11.08	1.93	39.37	53.29	116.14
CD ($P_{\leq 0.05}$)	2.18	0.88	1.12	1.30	0.23	0.86	1.32	0.10	1.62	2.00	2.85
Sub Plot – Biofertilizers											
No biofertilizer (B_0)	59.69	47.07	261.09	22.49	5.28	2.52	7.56	1.78	36.46	50.72	91.59
Azotobacter (B_1)	62.79	48.68	293.98	24.92	6.58	3.11	9.69	1.86	36.32	49.42	105.86
PSB (B_2)	60.62	49.84	285.42	25.98	6.65	2.98	9.58	1.88	34.57	48.28	110.21
KSB (B_3)	60.39	48.95	284.32	24.46	6.24	2.88	9.19	1.87	35.12	49.07	106.53
Azotobacter+PSB (B_4)	64.01	51.07	297.77	26.59	7.09	3.32	10.98	1.90	33.56	47.23	119.17
Azotobacter+KSB (B_5)	63.51	50.70	295.30	26.31	6.96	3.25	10.75	1.89	34.23	47.89	114.80
PSB+KSB (B_6)	62.24	50.39	293.27	27.03	7.10	3.12	10.08	1.88	33.16	47.06	112.03
Azotobacter+PSB+KSB (B_7)	65.04	52.19	304.81	28.44	7.77	3.42	11.72	1.93	32.54	46.31	122.21
CD ($P_{\leq 0.05}$)	0.99	1.22	1.53	1.27	0.25	0.28	1.21	N.S	1.05	1.50	1.84

N.S = Non-significant; PSB = Phosphate solubilising bacteria; KSB = Potassium solubilising bacteria

Table 2: Interaction effect of pinching and biofertilizers on growth and flowering in Globe amaranth (*Gomphrena globosa* L.)

Treatment	Plant height (cm)	Plant spread (cm)	Number of leaves plant^{-1}	Leaf area (cm^2)	Leaf area index (LAI)	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Stem diameter (cm)	Days taken to flower bud appearance	Days taken to 50% flowering	Number of flowers plant^{-1}
P_0 B_0	66.05	46.88	250.22	23.34	5.26	2.00	7.13	1.77	31.26	45.44	87.85
P_0 B_1	68.74	48.35	272.47	25.87	6.35	2.59	8.31	1.80	31.08	44.40	99.90
P_0 B_2	66.97	49.03	262.57	27.22	6.43	2.46	8.72	1.82	29.96	43.27	103.95
P_0 B_3	66.52	48.65	260.85	25.33	5.95	2.35	8.05	1.81	30.22	44.12	100.55
P_0 B_4	69.84	50.44	278.34	28.22	7.07	2.83	9.74	1.84	28.74	42.19	112.91
P_0B_5	69.26	50.00	275.05	27.98	6.93	2.77	9.33	1.84	29.37	43.01	108.77
P_0B_6	67.44	49.86	272.37	28.81	7.06	2.64	8.96	1.82	28.30	42.02	105.65
P_0B_7	71.05	51.67	284.04	29.91	7.65	2.92	10.20	1.87	28.04	41.22	116.09
P_1B_0	53.33	47.25	271.95	21.65	5.29	3.03	7.99	1.79	41.66	55.99	95.33
P_1B_1	56.84	49.01	315.50	23.97	6.80	3.63	11.07	1.92	41.55	54.44	111.81
P_1B_2	54.27	50.66	308.27	24.74	6.86	3.50	10.43	1.94	39.18	53.29	116.48
P_1B_3	54.25	49.26	307.77	23.59	6.54	3.41	10.33	1.93	40.02	54.01	112.51
P_1B_4	58.18	51.69	317.20	24.97	7.13	3.80	12.23	1.97	38.39	52.26	125.42
P_1B_5	57.75	51.40	315.56	24.65	7.00	3.72	12.17	1.95	39.08	52.77	120.84
P_1B_6	57.03	50.92	314.16	25.26	7.14	3.60	11.21	1.94	38.01	52.11	118.41
P_1B_7	59.02	52.72	325.57	26.96	7.89	3.93	13.23	1.99	37.05	51.40	128.33
CD ($P_{\leq 0.05}$)	N.S	N.S	2.69	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Conclusion

Based on the result of present study it is concluded that pinching 20 days after transplanting in Globe amaranth enhanced vegetative growth (plant spread, stem diameter, number of leaves per plant, LAI, primary and secondary branches per plant) and thus lead to increased number of flowers per plant thus increased yield. Among different biofertilizers the application of (*Azotobacter* + PSB + KSB) proved to be superior in case of almost all the vegetative parameters and significantly increased flower yield in Globe amaranth. Interaction effect of pinching and (*Azotobacter* + PSB + KSB) was found beneficial in improving various vegetative and floral characteristics.

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