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Effect of biofertilizers and GA_3 on growth, yield, quality and economics of drumstick (*Moringa* oleifera Lam.) cv. Bhagya

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ABSTRACT

A field experiment was carried out during *kharif* session of 2019-20 and 2020-21 at the Dryland Horticulture Farm, Sirsod, Gwalior (M.P.) to study the effect of biofertilizers and GA_3 on growth, yield and economics of drumstick. Application of 75% RDF (NPK) alongwith 50 g VAM fungi and 20 ppm GA_3 spray resulted in maximum growth, yield-attributes, seed yield and economics from drumstick var. Bhagya. The maximum growth parameters were 13.44 m plant height 13.07 branches/tree, leaflets 18.56/branch, 48.03 cm trunk girth and 10.49 LAI. The yield attributes were 138.74 flowers/cluster, 63.69 fruit sets, 162 pods/tree, 62.71 cm pod length, 44.74 pod of diameter and 15.31 seeds/pod. The total seed yield was 20.56 kg/tree alongwith maximum seed protein (21.41 %), monetary return upto Rs.3588/tree with 6.32 B:C ratio. The second and third best treatments were 75% RDF + 50 g PSB + 20 ppm GA_3,and 75% RDF + PMB + 20 ppm GA_3 spray, respectively.

Key words: Biofertilizers, GA_3, drumstick, var. Bhagya

INTRODUCTION

In recent years, the utilization of multi-purpose plants has shown interest in a dynamic way. One such plant is *Moringa oleifera* Lam, the most widely cultivated species of a mono-generic family Moringaceae. The drumstick was claimed to be the most nutrient-rich plant yet discovered (Khawaja *et al.* , 2010). Growth and biomass of *Moringa oleifera* plants affected significantly with the application of phosphate-solubilizing fungi individually and in combination with multiplex biofertilizers (Dash and Gupta, 2009). Biofertilizers became a positive alternative to chemical fertilizers. Because it is the most important for plant production and soil health in general as they play an important and complex role in plant growth, improving fruit quality and yield components of crops by way of various biochemical activities in the soil such as increases the soil fertility naturally, add nutrients through the natural processes biological N fixation, solubilizing phosphorus, the availability of nutrients by their biological activity and uptake of nutrients (Saraswati and Sumarno, 2008). Hence, to increase the productivity of the soil, the use of biofertilizer is a must it helps in stimulating the plant growth hormones, providing better nutrient uptake and increased tolerance towards drought and moisture stress. However the use of plant Growth regulators (PGR) might be a useful alternative to increase crop production. Recently, there has been global realization of the important role of PGRs in increasing crop yield. Gibberellic acid (GA_3) is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al.*, 2002). Hence, used of different combinations of biofertilizers and gibberellic acid will induce positive impact on the nutrient status and will also develop effective fruiting and seed yield of drumstick plant. Keeping these points in view, the present investigation was taken up.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* seasons of 2019-20 and 2020-21at the Dryland Horticulture Farm Sirsod, Gwalior (M.P.). The soil of the experimental field was clay-loam having pH 7.8, electrical conductivity 0.39 dS/m, available N, P_2O_5, K_2O, S was202, 11.16, 425, 8.89kg/ha, respectively. The rainfall received during June to December was 843 and 638 mm in both the years. The 16 treatments comprised of T_0-control, T_1-100 % RDF, T_2 to T_{15} 75 % RDF with VAM fungi (VA-mycorrhiza) or PSB (Phosphate-solubilizing bacteria) or PMB (phosphate-mobilizing mycorrhiza) or *Azotobacter* with GA_3 @ 10 and 20 ppm under their different combinations. Thus treatments were laid out in the randomized block design keeping three replications. There were total 48 one-year old drumstick trees var. Bhagya planted under 2 m x 3 m spacing. The 100 % RDF was applied @ 23:18:28 NPK kg/ha i.e. 13.8:10.8:16.8 g NPK /tree. The biofertilizers were applied @ 50 g/trees and GA_3 was foliar sprayed @ 10 and 20 ppm as per treatments. The drumstick tree were allowed to grow as per recommended package of practices. The periodical observations on growth and yield-attributing and yield parameters were recorded. The seed protein was determined as per A.O.A.C. (1997)

procedure. The periodical data thus obtained wore subjected to statistical computation before presenting the results.

RESULTS AND DISCUSSION

Growth characters

The data in Table 1n indicate their the best treatment was T_{15} having 75% RDF + 50 g VAM fungi + 20 ppm GA_3 which raised the plant height upto maximum extent (13.44 m), branches 13.07 /plant, leaflets 18.56/branch, trunk girth 48.30 cm, tree spread 42.96 cm and leaf area index upto 10.49. The second, third and fourth best treatments were T_{14} (75% RDF + PSB + GA_3 20 ppm) T_{13}(75% RDF + PMB + GA_3 20 ppm) and then T_{12} (75% RDF + *Azotobactor* + GA_3 20 ppm), respectively.

In these four treatments (T_{12} to T_{15}), RDF and GA_3 doses were the same but the biofertilizers applied were different, therefore it is quite apparent that VAM fungi (VA-mycorrhiza) proved most effective than PSB (phosphate-solubilizing bacteria), PMB (phosphate-mobilizing mycorrhiza) *or Azotobacter*. In order to meet out the nutritional requirement of drumstick the applied NPK chemical fertilizers along with biofertilizers and GA_3 played their own well known functions.

It is worthy to mention that amongst the growth parameters, the formation of leaves is the most important factor because leaves are the food processing units or photosynthetic surface areas. In fact, leaf is the factory for the conversion of solar energy into the chemical energy by the process of photosynthesis (Kar and Chakravarty, 2001). The photosynthetic efficiency of leaves is the measure of their area, weight and distribution of assimilates to the sink for net productivity per unit time. Thus the LAI was enhanced upto maximum extent due to T_{12}, T_{13}, T_{14} and T_{15} treatments having sufficient nutritional requirement as well as growth promoting substances.

The remarkable increase in plant height, formation of higher number of branches /tree, leaflets /branch, trunk girth and tree spread as well as leaf area index (LAI) under T_{15}, T_{14}, T_{13} and then T_{12} treatments was on account of acceleration of cell elongation, expansion and cell division under sufficient supply of nutrients as well as other beneficial role of the applied inputs i.e. VAN fungi and higher 20 ppm dose of GA_3. The VAM symbiosis might have increased soil quality, profuse root-development, phosphorus and micronutrient uptake and growth of their host plant. GA_3 is a important growth regulator that have many uses to modify the growth, yield and yield contributing characters of plant (Rafeekher*et al*. 2002). Gibberellins function as hormones in plant, affecting the growth and differentiation in organs in which their concentration is very tightly regulated Dubey*et. al*., 2010).

These results are in close conformity with the observations made by Chhuria*et al*., 2016; and Adiaha, 2017, Pradip Kumar and Sharma 2018 in case VAM and other of biofertilizes, whereas Kumar *et al*., 2003, Amaya-Carpio*et al*. (2009), and in case of GA_3.

Yield-attributes and yield

The factors which are directly responsible for ultimate seed production viz. number of pods /tree fresh and dry weight of pods/tree, pod length, diameter and seeds formation per pod were augmented significantly due to application of 75% RDF + VAM fungi + GA_3 20 ppm (T_{15}), 75% RDF + PSB + GA_3 20 ppm (T_{14}), 75% RDF + PMB + GA_3 20 ppm (T_{13}) and then 75% RDF + *Azotobacter* + GA_3 20 ppm (T_{12}) treatments. The treatment T_{15} recorded maximum 162 pods /tree, fresh and dry weight of pods 2859 and 305 g/tree, respectively, 62.71 cm pod length, 44.74 cm pod diameter and 15.31 seeds /pods Consequently the highest seed yield was recorded upto 20.56 kg/tree.

The tremendous enhancement in growth parameters and there by significant increase in yield attributing characters and yield of drumstick due to T_{15} applied with 75% RDF + VAM fungi + 20 ppm GA_3 might be due to the fact that these combined inputs enhanced the number and growth of young leaflets/ branch which helped in the synthesis of carbohydrates, proteins etc. for building up new tissues and eventually increase in the seed yield. According to Joseph. (2015) phosphate-mobilizing or phosphorus-solubilizing biofertilizers/ microorganisms (bacteria, fungi, mycorrhiza etc.) converts insoluble soil phosphate into soluble forms by recreating several organic acids and under optimum conditions they can solubilize and mobilize about 30-50 kg P_2O_5/ha due to which crop yield may increase by 10 to 20%. The present results corroborate with the findings of many researchers (Makinde Adremi Isaiah, 2013; Chhuria *et al*., 2016; Vijay Kumar *et al*., 2012; Ndukare *et al*., 2011; Pradip Kumar and Sharma, 2018).

Dubey *et al.* (2010) reported that the significant effect of GA_3 may be owing to the better growth modifications and proper utilizations of the nutrients which produced the maximum floral characters of the gladiolus plants. The maximum size and longer leaves where produced by GA_3 which manufactured sufficient amount of carbohydrates during photosynthesis which ultimately translocated to the sink.

Protein content in seeds

The data in Table 2 revel that theprotein content in drumstick seeds was augmented upto significant extent (21.41 %) under T_{15} treatment (75 % RDF + VAM fungi + 20 ppm GA_3) over rest of the treatments. However this was followed by T_{14} (75 % RDF + PSB + 20 ppm GA_3) 21.13 %, T_{13} (75 % RDF + PMB + 20 ppm GA_3) 20.85 % and then T_{12} (75 % RDF + *Azotobacter* + 20 ppm GA_3) 20.82 % seed protein. The combined impact of NPK fertilizers, biofertilizers and growth regulator GA_3 in improving seed quality may be attributed to their significant role in regulating the photosynthesis, root enlargement and better microbial activities (Saraswati and Sumarno. 2008 and Pradip Kumar and Sharma, 2018). The higher grain protein may be owing to the increased synthesis of protein through amino acids as a result of N-metabolism (Patel *et al*., 2005). Moreover the highest protein may be accrued owing to sufficient and prolonged supply of N to the developing plants which is a constituent of amino acid precursor of protein synthesis Saket *et al.* (2017).

Economical gain/tree

The higher level of applied nutrients particularly in case of T_{15} having 75 % RDF +VAM fungi + 20 ppm, GA_3 recorded maximum net income upto Rs.3588/ tree with 6.32 B:C ratio. The second best treatment was T_{14} having 75 % RDF + PSB + 20 ppm GA_3 the net income being upto Rs.3786/tree with 5.59 B:C ratio. The third best treatment was T_{13} having 75 % RDF + PMB 20 ppm GA_3, the net income being upto Rs.2962/tree with 5.21 B:C ratio. The net income in other treatments were decreased due to decrease in the productivity of drumstick. The control treatment recorded the minimum net income only Rs.1581/tree with 2.81 B:C ratio. Thus, the net income was exactly in accordance with the productivity under each of the treatments which fetched market value.

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Table 1 Growth yield attributing characters and yield of drumstick as influenced by biofertilizers and GA_3

Treatments	Plant height (m)	Branches per tree	Leaflets per branch	Trunk girth (cm)	Leaf area index	Flowers per cluster	Fruit sets (%)	Pods per tree	Pod length (cm)	Pod diameter (cm)	Seeds per pod	Total seed yield per tree (kg)
T_0	3.79	4.80	6.27	27.50	3.06	16.54	25.26	62	32.64	11.15	7.67	10.25
T_1	5.28	5.74	9.61	37.54	4.23	29.01	37.72	73	42.11	12.82	10.26	12.38
T_2	4.88	6.24	10.42	34.83	4.91	19.65	29.45	84	48.52	13.99	10.33	12.69
T_3	5.76	6.58	10.95	38.54	5.72	57.80	42.75	91	51.08	17.61	10.60	13.41
T_4	6.02	7.09	12.37	40.33	6.61	82.06	44.01	94	51.89	21.54	10.87	13.92
T_5	7.51	8.21	12.55	41.02	7.53	82.65	46.64	97	53.16	22.81	11.21	14.37
T_6	7.61	8.63	13.39	41.73	8.49	84.01	48.40	102	54.77	23.80	11.41	14.74
T_7	8.12	9.08	13.51	42.88	8.97	85.78	49.73	105	55.85	31.33	11.68	15.06
T_8	8.97	9.69	13.97	44.04	9.30	98.82	50.38	108	57.52	33.98	12.06	15.55
T_9	9.63	10.29	14.54	45.09	9.41	110.36	51.21	115	58.33	38.13	12.40	15.84
T_{10}	10.33	10.87	14.97	45.83	9.84	115.99	51.92	123	58.61	40.77	12.56	16.22
T_{11}	10.86	11.25	15.32	46.43	9.93	128.91	52.57	128	59.04	42.27	13.39	17.27
T_{12}	11.20	11.59	15.55	46.97	10.09	133.16	53.45	135	60.08	43.29	13.67	17.92
T_{13}	11.96	12.26	16.19	47.38	10.19	135.30	54.39	143	61.86	43.62	14.23	18.69
T_{14}	12.50	12.66	17.21	47.70	10.34	137.12	62.62	152	62.49	44.29	14.51	19.22
T_{15}	13.44	13.07	18.56	48.30	10.49	138.74	63.69	162	62.71	44.74	15.31	20.56
S.Em±	**0.08**	**0.10**	**0.02**	**0.16**	**0.04**	**0.53**	**0.53**	0.78	**0.23**	**0.18**	**0.01**	**0.05**
C.D. (P=0.05)	**0.24**	**0.28**	**0.05**	**0.45**	**0.12**	**1.54**	**1.54**	2.24	**0.65**	**0.53**	**0.04**	**0.15**

Table 2 Growth parameters, seed protein and economics from drumstick as influenced by biofertilizers and GA_3

Treatments	Tree spread (cm)	Fresh weight pods /tree (g)	Dry weight of pods/ tree (g)	Protein content in seed (%)	Net income (per/ tree)	B:C ratio
T_0	22.84	993	140	14.49	1581	2.81
T_1	33.15	109	273	20.83	1970	3.49
T_2	34.27	1110	251	20.24	2010	3.58
T_3	34.74	1152	252	20.44	2183	3.87
T_4	37.76	1160	254	20.48	2191	3.89
T_5	39.31	1407	255	20.51	2386	4.22
T_6	39.89	1437	255	20.59	2396	4.23
T_7	40.33	1493	255	20.61	2403	4.23
T_8	40.42	1551	256	20.64	2568	4.51
T_9	40.48	1578	257	20.66	2580	4.54
T_{10}	40.91	1583	262	20.73	2587	4.51
T_{11}	41.20	1747	267	20.76	2911	5.09
T_{12}	41.73	1818	276	20.82	2950	5.14
T_{13}	42.32	2091	282	20.85	2962	5.21
T_{14}	42.43	2623	301	21.13	3186	5.59
T_{15}	42.96	2859	305	21.41	3588	6.32
S.Em±	**0.37**	**35.35**	**1.69**	**0.05**	--	--
C.D. (P=0.05)	**1.06**	**102.10**	**4.89**	**0.14**	--	--