International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 834-836

Received: 15-09-2020
Accepted: 26-10-2020

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Effect of granulated lime and bio-inoculants on the productivity of French bean (*Phaseolus vulgaris* L.) under hilly zone of Karnataka

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6l.10874

Abstract
A field experiment was conducted at College of Horticulture, Mudigere, Chikamagalur district, Karnataka to investigate the effect of granulated lime and bio-inoculants on the productivity of French beans (*Phaseolus vulgaris* L.) under the hilly zone of Karnataka during late *rabi* season 2019-20. The experiment was laid out in RCBD with nine treatments replicated thrice. The treatments consisted of granulated lime at three levels (100, 75 and 50 % LR) and agriculture lime at 100 % LR, with and without bio-inoculants. RDF and FYM were common to all treatments. The liming materials were applied based on SMP (Shoemaker, Mclean and Pratt) buffer method. The results revealed that significantly higher plant height (51.1 cm), number of branches (6.88 plant^{-1}), number of leaves (26.42 plant^{-1}), chlorophyll content (49.64 SPAD) and dry matter accumulation (19.34 g plant^{-1}), pod number (21.43 plant^{-1}), pod length (15.67 cm), pod weight (177.17 g plant^{-1}), green pod yield (12.93 t ha^{-1}) and stover yield (2.93 t ha^{-1}) over control.

Keywords: Agriculture lime, Bio-inoculants, French bean, Granulated lime, Growth and Yield

Introduction
French bean (*Phaseolus vulgaris* L.), also known as a green bean or common bean, is an annual herbaceous plant family Fabaceae. Bean are called "meat of the poor", contribute essential protein to the undernourished people. It is cultivated worldwide and contributes nearly 30 *per cent* of food legumes total production (Vasishtha and Srivastava, 2012). In India, green beans are cultivated over 0.24 mha with a production of 0.67 m t and 27,940 kg ha^{-1} productivity. The dry beans are cultivated in an area of 15.42 m ha with a production of 6.39 m t and 4,142 kg ha^{-1} productivity. In Karnataka, it is grown on an area of 15,699 ha with a total production of 16,785 tonnes and productivity of 11 t ha^{-1} (Anon., 2017). It is rich It is a rich source of nutrient and minerals *viz*., protein content 17.5 to 28.7 *per cent* in dry seeds and 1.0 to 2.5 *per cent* in green pods, 3.2 to 5.0 *per cent* mineral matter, 4.2 to 6.3 *per cent* crude fiber, 1.2 to 2.0 *per cent* crude fat and 340 to 450 K cal energy, 0.16 mg iron, 1.76 mg calcium and 3.43 mg zinc per 100 g of the edible part (Sardana *et al*., 2000) [6] and has many other medicinal uses.

In India, approximately one-third of the cultivated land is affected by soil acidity. The majority of these soils are concentrated in India's northeastern region, with nearly 65 *per cent* of its area being under extreme forms of soil acidity with pH below 5.5. (Sharma and Singh, 2002) [7]. Out of the 19.2 m ha of the geographical area in Karnataka, nearly 9.6 m ha (50 *per cent* of the total area) is acidic spanning spanned across the districts of Dakshina Kannada (72 %), Uttara Kannada (65 %), Kodagu (40 %), Chickmagalur (39 %), Shivamogga (33 %), Hassan (20 %), Mysore (15 %), Mandya (12 %), Bangalore (10 %) and Belgaum (10 %) (Ananthanarayana, 1996) [1].

It creates unfavourable environment in the soil due to iron and aluminium toxicity and reduced microbial activity, thereby the productivity of crops grown on acid soils are reduced. Applying liming materials is the best management practice to reclaim acid soils. Granulated lime is an agglomeration of very finely ground and or micronized particles of calcium or magnesium

carbonate (limestone) with at least 90 *per cent* passing a 150-micron sieve with binders like clay and lignosulfonates added to the powder to make it granules.

Keeping these things in view the experiment was conducted to know the effect of granulated lime and bio-inoculants on fsrench bean.

Material and Methods

A field experiment was conducted during late *rabi* season of-2019 at College of Horticulture, Mudigere, UAHS, Shivamogga which is situated in the Hilly Zone (Zone-9) of Karnataka. The geographical reference point of the experimental site was 13° 7' North latitude and 74° 37' East longitude and at an altitude of 980 m above the mean sea level. The soil was sandy loam in texture, highly acidic pH (4.52) and low in electrical conductivity (0.033 dS m^{-1}), medium organic carbon 0.58 % and medium in available nitrogen and phosporus (288.68 and 31.88 kg ha^{-1}, respectively), and low in potassium status (98.73 kg K_2O ha^{-1}). During the experiment period, the total actual rainfall received was 419.90 mm.

Field experiment was laid out in randomized complete block design with nine treatments and three replications. Treatments consisted of agriculture (powder lime), different levels of granulated lime with or without bio-inoculants (*Azatobacter*, PSB, KSB) *viz.*, T_1: RDF + FYM (control), T_2: T_1+ agriculture lime @ 100% LR, T_3: T_1+ agriculture lime @ 100% LR + bio-inoculants, T_4: T_1+ granulated lime @ 100% LR, T_5: T_1+ granulated lime @ 75% LR, T_6: T_1+ granulated lime @ 50% LR, T_7:T_1+ granulated lime @ 100% LR + bio-inoculants and T_8:T_1+ granulated lime @ 75% LR + bio-inoculants, T_9:T_1+ granulated lime @ 50% LR + bio-inoculants. The lime requirement for experimental site was measured by SMP buffer method (Shoemaker *et al.*, 1961) and granulated lime (dolomite) was applied based on calcium carbonate equivalent (CCE) value. The lime requirement (LR) was found to be 16.25 t ha^{-1}. The variety used is Arjun, developed by United Genetics India Private Limited. Bio-inoculants were mixed with farm yard manure at the rate of 650 ml ha^{-1}, incorporated into soil and the liming materials were spread (broadcasted) on the soil surface as per treatments. The liming materials and FYM were applied in the month of November. All the biometric observations recorded were subjected to analysis.

Results and Discussion

Effect of granulated lime and bio-inoculants on the growth and development of French bean

Significantly higher growth parameters were recorded in the treatment received T_1+ granulated lime @ 100% LR + bio-inoculants (T_7) compared to control at 20, 40 DAS and at harvest

The plant height progressively increased with advancement in the age of crop, significantly higher plant height (17.87, 46.36 and 51.18 cm was recorded at 20, 40 DAS and at harvest, respectively). This increase in plant height in french bean might be due to favourable soil condition created by the application of lime, FYM and bio-inoculants and the reduced harmful effect of iron and aluminium in the soil. These findings are in line with the Dinesh Varma *et al.* (2017) and Mohanty *et al.* (2017) [5].

Like tillering in cereals, branching is an important growth parameter in pulse crops like french bean. The number of branches per plant determines the yield parameters like number of flowers per plant and number of pods per plant. Significantly maximum number of branches (1.07, 6.48 and 6.88 $plant^{-1}$ at 20, 40 DAS and at harvest, respectively) and highest number of leaves $plant^{-1}$ (6.63, 26.22 and 26.42 $plant^{-1}$ at 20, 40 DAS and at harvest, respectively) was noticed in the treatment T_7. The availability of nutrients at initial stages of crop growth due to the action of lime, FYM, biological nitrogen fixation and phosphorous and potassium solubilisation by the bio-inoculants, improved rate of photosynthesis and translocation of photosynthates could have helped in obtaining higher number of branches and leaves per plant..

The liming materials and bio-inoculants significantly influence the chlorophyll content in the leaves. The highest chlorophyll (SPAD) was recorded with the application of 100% RDF + FYM + granulated lime @ 100% LR+ bio-inoculants (T_7) at 20, 40 DAS and at harvest (38.47, 56.58 and 49.64, respectively). The chlorophyll content was relatively higher in granulated lime treatments than agriculture lime treatments due to its higher magnesium content. This improved the photosynthetic activity of the leaves. Similar observations were made by Tupaki *et al.* (2017) [10] and Bhindhu *et al.* (2018) [3]

Total dry matter (TDM) accumulation is a significant index representing the plant's growth and metabolic efficiency which ultimately influences crop yield. The amount of TDM produced indicates the overall efficiency of resource utilisation and better interception of light. Significantly higher total dry matter production (2.64, 7.34 and 19.34 g $plant^{-1}$ at 20, 40 DAS and at harvest, respectively) were produced in the treatment T_7. The increase in plant height, number of leaves and number of branches per plant resulted in greater total dry matter accumulation. The improvement in chlorophyll content and photosynthetic leaf area might have led to better interception, absorption and utilization of solar energy, leading to a higher photosynthetic rate and finally higher production and accumulation of photosynthates. The increase in the nutrient uptake due to lime and bio-inoculants' action might have also helped maintain a higher auxin content level, which might have resulted in better plant height, number of leaves, and leaf area of the crop.

Effect of granulated lime and bio-inoculants on the yield parameters and yield of French bean

The green pod yield is governed by number of factors which have direct or indirect impacts. It can be enhanced by improving the yield attributing characters *viz.*, number of pods per plant, pod weight per plant and pod length.

In the present investigation, application of RDF + FYM + granulated lime @ 100% LR + bio-inoculants increased the growth and yield attributing characters and it may be due to the greater assimilatory leaf area as it is a major source for supplying assimilates to the developing pods. Significantly higher number of pods $plant^{-1}$ (21.43), pod length (15.67 cm) and pod weight (177.17 g $plant^{-1}$), followed by T_3 and T_8. Similar results were observed by Sultana *et al.* (2019). The increase in the number of branches increases the flowering points and hence the number of pods per plant. The improved photosynthetic activity led to efficient production and translocation of photosynthates from source to sink this reflects on the production of better yield attributing parameters like pod length and weight. The green pod and stover yield (12.93 and 2.93 t ha^{-1}) increased due to more number of pods per plant and heavier pods due to increased accumulation of photosynthates. The use of bio-inoculants helped in crop production by improving nutrient availability.

Conclusion

The application of RDF + FYM + granulated lime @ 100 % LR + bio-inoculants increased the growth, yield parameters and yield (12.93 t ha^{-1}) of french bean under Hilly zone of Karnataka and helped in sustainable crop production. The granulated lime performed better than agriculture lime due to slow release, longer existence in soil, reduced leaching and runoff loss and higher magnesium content. It can be used as an alternate source to ameloriate soil acidity.

Table 1: Effect of granulated lime and bio-inoculants on growth parameters of French bean

Treatments	Plant height (cm.)			No. of branches $plant^{-1}$			No. of leaves $plant^{-1}$			Chlorophyll content (SPAD)			Total dry matter (g $plant^{-1}$)		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1	14.61	34.84	38.47	1.08	4.97	5.27	5.30	16.44	17.76	34.31	47.07	39.14	2.44	4.23	11.09
T_2	17.19	41.84	46.03	1.01	5.88	6.21	5.77	21.93	22.85	34.91	49.92	43.39	2.51	6.41	17.26
T_3	17.66	20.88	50.47	1.05	6.47	6.76	6.27	25.52	25.85	35.09	50.18	43.62	2.57	7.19	18.76
T_4	17.22	42.17	46.39	1.02	6.12	6.44	5.90	22.32	24.18	37.29	54.29	47.32	2.52	6.73	18.95
T_5	16.97	41.57	20.91	1.05	5.57	5.82	5.70	21.81	22.50	36.06	51.56	44.86	2.49	6.20	16.77
T_6	16.11	39.10	43.01	1.04	5.19	5.51	5.48	18.40	19.93	35.12	50.42	43.82	2.43	5.63	14.09
T_7	17.87	46.36	51.18	1.07	6.48	6.88	6.63	26.22	26.42	38.47	56.58	49.64	2.64	7.33	19.34
T_8	17.38	44.68	49.15	1.03	6.36	6.64	6.00	25.49	25.61	36.48	53.26	46.32	2.55	7.01	18.25
T_9	16.81	41.18	44.86	1.08	5.39	5.75	5.59	19.15	21.02	35.64	51.32	44.36	2.47	5.76	14.39
S. Em.±	0.98	2.42	2.51	0.01	0.24	0.32	0.98	2.42	2.51	0.71	1.43	1.79	0.03	0.79	2.02
CD @ 5%	2.91	7.26	7.47	NS	0.74	0.96	NS	7.26	7.47	2.11	4.27	5.35	0.09	2.36	6.03

RDF @ 63:100:75 $N:P_2O_5:K_2O$ FYM @ 25 t ha^{-1}.

Table 2: Effect of granulated lime and bio-inoculants on yield and yield parameters of French bean

Treatment details	no. of pods ($plant^{-1}$)	pod length (cm)	pod weight (g $plant^{-1}$)	Green pod yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1 : RDF + FYM	15.88	10.96	110.29	8.71	2.32
T_2 : T_1+ agriculture lime @ 100% LR	19.23	13.92	160.64	11.79	2.64
T_3 : T_1+ agriculture lime @ 100% LR + bio-inoculants	20.43	15.39	173.48	12.87	2.86
T_4 : T_1+ granulated lime @ 100% LR	19.84	14.19	165.29	12.11	2.67
T_5 : T_1+ granulated lime @ 75% LR	18.52	13.66	157.78	11.58	2.57
T_6 : T_1+ granulated lime @ 50% LR	17.19	13.25	140.97	10.33	2.43
T_7 : T_1+ granulated lime @ 100% LR + bio-inoculants	21.43	15.67	177.17	12.93	2.93
T_8 : T_1+ granulated lime @ 75% LR + bio- inoculants	20.24	15.09	169.19	12.44	2.74
T_9 : T_1+ granulated lime @ 50% LR + bio- inoculants	18.35	13.57	151.22	10.57	2.51
S. Em ±	1.10	1.11	17.53	1.28	0.09
C. D. at 5%	3.30	3.31	52.22	3.82	0.27

RDF @ 63:100:75 $N:P_2O_5:K_2O$ FYM @ 25 t ha^{-1}.

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