www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 1901-1907

www.thepharmajournal.com
Received: 01-04-2023
Accepted: 09-05-2023

Aishwarya Golshetti
Department of Agronomy, College of Agriculture V. C. Farm Mandya, Karnataka, India

G Somanagouda
All India Coordinated Research Project on Soybean, MARS, University of Agriculture Sciences, Dharwad, Karnataka, India

Shivashankar K
Ph. D. Scholar, Department of Agronomy, College of Agriculture, Dharwad University of Agriculture Sciences, Dharwad, Karnataka, India

Hanamantappa Meti
Department of Soil Science and Agriculture Chemistry, College of Agriculture V. C. Farm Mandya, Karnataka, India

Corresponding Author:
Aishwarya Golshetti
Department of Agronomy, College of Agriculture V. C. Farm Mandya, Karnataka, India

Bio-efficacy of biostimulants on growth indices of *Glycine max* (L.) Merr.

Aishwarya Golshetti, G Somanagouda, Shivashankar K and Hanamantappa Meti

Abstract
Soybean (*Glycine max* (L.) Merr.) is one of the major oilseed crops in the world. A study was conducted at Main Agricultural Research Station, University of agricultural sciences Dharwad. Plant biostimulants contain substance(s) and/or micro-organisms when applied to plants stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality. 1st spray of biostimulants was taken up 5 days prior to the flowering, and the crop was in pod formation stage on 52 DAS, 8 days later 2nd spray of biostimulant was taken up. Significantly higher growth parameters such as leaf area (11.47 dm^2 $plant^{-1}$), leaf area index (3.82) and dry matter accumulation (72.25 g $plant^{-1}$), between 30-60 DAS, AGR (2.062 g day^{-1}) and CGR (68.72 g m^{-2} day^{-1}) and between 60 DAS to harvest, AGR (0.211 g day^{-1}), CGR (7.02 g m^{-2} day^{-1}) and biomass duration (1239.7 g days $plant^{-1}$) were recorded with foliar application of Crop Max @ 750 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_8). Crop Max as a biostimulant @ 750 ml ha^{-1} followed by Biozyme @625 ml ha^{-1} has a significant influence on the growth parameters and growth indices.

Keywords: Biostimulants, *Glycine max* (L.) Merr., pod formation

Introduction
Soybean (*Glycine max* (L.) Merr.) is one of the major oilseed crops in the world. In the world, United States, Brazil, Argentina, China and India are the largest producers and exporters of soybean, concentrating more than 80 per cent of total production and 90 per cent of total exports, with total production of the world being 385.52 mt (SOPA, data bank 2021-22).
Many studies on biostimulants have been reported on the productivity of soybean and other field crops (Kocira, 2018, Avornyo *et al*., 2020) [25, 3] (12% increase of yield over conventional method), (Rehman *et al*., 2018, Pashupatimath, 2018, Kavita *et al*., 2008, Singh *et al*., 2021, Kumawat *et al*., 2015) [20, 26, 11, 27, 15]. "Plant biostimulants contain substance(s) and/or micro-organisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to enhance/ benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality (Calvo *et al*., 2014) [28]. Agronomist mainly emphasis on crop productivity and biostimulants are crop, cultivar and location-specific their suitability must be known on the productivity (Kocira, 2018) [25]. Biostimulants do not directly take part in increasing the crop yield but focuses on making the plant hardy for harsh prevalent biotic and abiotic stresses such as drought (Vasconcelos *et al*., 2009) [29], water stress (Delfine *et al*., 2005) [5], insect (Huang *et al*., 2018) and pest attack, salinity (Calvo *et al*., 2014) [28] of the soil etc., thus support the plants in escaping these stresses. Humic acid application on wheat under Pot trial with calcareous and noncalcareous field soils with three levels of N, P, and K increased plant height and dry weight of shoots (Tahir *et al*., 2011) [23]. Fulvic acid application on Maize under Pot trials in net house under drought and no drought conditions increased leaf area, plant dry weight and yield under drought stress (Anjum *et al*. 2011) [2]. Application of Maize grain extract + Mg reported increase of dry weight by 104.3% of harvested progeny of sunflower (Rehman *et al*., 2018) [20]. Pro-soil biostimulant as a stand-alone management practice increased dry matter by 42 per cent (Avornyo *et al*., 2020) [3]. Dry Matter contents of sunflower and corn increased by increasing rates of K-Humate application to soil and foliage (Ay dm *et al*., chapter-57). By keeping above reviews in view, the study was conducted on "Influence of biostimulants (Crop Max®) on growth indices of the soybean in zone-8 of Karnataka".

Materials and methods

A study was conducted in northern transitional zone of Karnataka, at Main Agricultural Research Station, University of agricultural sciences Dharwad on Bio efficacy of biostimulants on growth indices of soybean. The soil of the experimental site was in neutral p^H (7.1), normal electrical conductivity (0.32 dS m^{-1}), low in organic carbon content (0.44%), low in available nitrogen content (263 kg ha^{-1}) medium in available phosphorus (30.5 kg ha^{-1}), high in available potassium content (366 kg ha^{-1}) crop period was from 23/06/2021 to 30/09/2021 flower initiation was seen on 35 days after the sowing were the 1st spray of biostimulant was taken up 5 days prior to the flowering, and the crop was in pod formation stage on 52 DAS 8 days later 2nd spray of biostimulant was taken up, the physiological maturity was observed by visual methods such as turning of the leaves and pods to golden yellow colour. Observations were taken at 30 DAS, 60 DAS and at the time of harvest. The statistical design adopted for experimentation was Randomised Block design consisting of 11 treatments replicated thrice. Crop variety chosen was MACS-1188 from Pune, and was raised on the rainfall without any external irrigation. Total of 33 plots were there with gross plot size of 21.6 m^2 and net plot size of 11.52 m^2. Treatments consisting of T_1- Crop Max @ 375 ml ha^{-1}, T_2- Crop Max @ 500 ml ha^{-1}, T_3-Crop Max @ 625 ml ha^{-1}, T_4- Crop Max @ 750 $mlha^{-1}$ (T_1-T_4 double spraying of Crop Max at flower initiation and at pod formation stage), T_5- Crop Max @ 375 ml ha^{-1} and Biozyme @ 625 ml ha^{-1}, T_6- Crop Max @ 500 ml ha^{-1} and Biozyme @ 625 $mlha^{-1}$, T_7- Crop Max @ 625 ml ha^{-1} and Biozyme @ 625 $mlha^{-1}$, T_8- Crop Max @ 750 ml ha^{-1} and Biozyme @ 625 $mlha^{-1}$, T_5-T_8 Crop Max at flower initiation followed by Biozyme at pod formation stage T_9-Biozyme @ 625 ml ha^{-1} at both stages, T_{10}-Control-1 (Urea @ 2% and KNO_3 @1% spray) and T_{11}-Control-2 (water spray) along with RDF (FYM @ 6.25 t + 40:80:25 kg N: P_2O_5 and K_2O + $ZnSO_4$ @ 12.5 kg + *Rhizobium* and PSB @ 1250 g each per hectare) common to all treatments (For T_1 to T_{10}, foliar application at flower initiation (25-35 DAS) and at pod formation stage (45 – 50 DAS). crop Max contains liquid nutrient supplement containing 24 per cent organic compounds (fermentation metabolites, selected marine algae and protein hydrolysates) + 18 per cent mineral components (https://www.corteva.in/). In order to determine the growth indices such as leaf area index (LAI), Leaf Area Ratio (LAR) and leaf area duration (LAD) on the basis of leaf area which were recorded at 30DAS and 60 DAS and AGR, CGR and Biomass duration (BMD) on the basis of dry weights recorded at 30 DAS, 60 DAS and at harvest the crop growth nature and extent of relation between growth indices and the yield was determined using the regression analysis in Microsoft excel software.

Leaf area

Leaf area was measured by disc method and expressed in decimeter square (dm^2). And was calculated by,

$$\text{Leaf area} = \frac{Wa \times A}{Wb}$$

Where,
LA = Leaf area (dm^2 $plant^1$)
W_a = Oven dry weight of all leaves (inclusive of disc weight)
W_b = Oven dry weight of 50 discs in gram
A = Area of the 50 discs (dm^2).

Leaf area index

Leaf area index was worked out by dividing the leaf area per plant by land area occupied by the plant (Sestak *et al.*, 1971) [6].

$$\text{LAI} = \frac{\text{Leaf area per plant (dm}^2\text{ per plant)}}{\text{Land area occupied by plant (dm}^2\text{)}}$$

Leaf Area Ratio (LAR)

The term, Leaf Area Ratio (LAR) was suggested by Radford (1967) [19] and expressed in cm^{-2} g^{-1} of plant dry weight.

$$\text{LAR} = \frac{\text{Leaf area per plant (cm}^2\text{ per plant)}}{\text{Plant dry weight (g}^{-1}\text{)}}$$

Leaf Area Duration (LAD)

To correlate dry matter yield with LAI, Power *et al.* (1967) [18] and LAD is expressed in days and was calculated by,

$$\text{LAD} = \frac{L_2 + L_1}{2}\ (t_2 - t_1)$$

Where,
L_1 = LAI at the first stage
L_2 = LAI at the second stage
(t_2 - t_1) = Time interval in days
Absolute growth rate (AGR)
It is expressed as g of dry matter produced in a day. *i.e.*, g day^{-1}. It is calculated by the formula, (Sharma, 2014) [30]

$$\text{AGR} = \frac{W_2 - W_1}{(T_2 - T_1)}$$

Where,
W_1 and W_2 are dry matter at time t_1 and t_2, respectively.
Crop growth rate (CGR)
It is the rate of growth of crop per unit area and expressed as g m^{-2} day^{-1} and was calculated by the formula,

$$\text{CGR} = \frac{W_2 - W_1}{(T_2 - T_1)\ P}$$

Where,
W_1 and W_2 are dry matter at time t_1 and t_2, respectively.
P is the land area.
Relative growth rate (RGR)
It is expressed as g of dry matter produced by a g of existing dry matter in a day. *i.e.*, g
g^{-1} day^{-1}. It is calculated by the formula, (Sharma, 2014) [30]

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,
W_1 and W_2 are dry matter at time t_1 and t_2, respectively.
Net assimilation rate (NAR)
It is expressed as g of dry matter produced per dm^2 of leaf area in a day *i.e.*, g dm^{-2}
day^{-1}. It is calculated by the formula, (Sharma, 2014) [30]

$$NAR = \frac{(W_2 - W_1)(Log_e LA_2 - Log_e LA_1)}{(t_2 - t_1)(LA_2 - LA_1)}$$

Where,
W_1 and W_2 are dry matter at time t_1 and t_2, respectively and LA_1 and LA_2 are leaf area at time t_1 and t_2, respectively,
Biomass duration (BMD)
The BMD is the integral of total biomass over a period and is expressed in g days. It is calculated by using the formula (Sharma, 2014) [30]

$$BMD = \frac{TDM_1 + TDM_2}{2}(t_2 - t_1)$$

Where, TDM is Total Dry Matter at time t_1 and t_2

Statistical analysis
The experimental data obtained at different growth stages was compiled and subjected to statistical analysis by adopting Fischer's method of analysis of variance technique as outlined by Gomez and Gomez (1984) [8]. The level of significance used in 'F' test will be at 5 per cent. Collected data were subjected to the proper of statistical analysis of variance (ANOVA) of randomised complete block design as mentioned by Gomez and Gomez (1984) [8]. Regression analysis between yield and growth indices was worked out by simple linear regression in Microsoft excel.

Results and discussion
The analysis of variance (ANOVA) for seed yield of soybean under varied concentrations of Crop Max and are presented in Table 1. It is evident that seed yield significantly varied due to treatments (T_1-T_{11}), as indicated by five percent level ($p < 0.05$) of significance.
Significantly higher leaf area (11.47 dm^2 $plant^{-1}$), leaf area index (3.82) and dry matter accumulation (72.25 g $plant^{-1}$) were recorded with foliar application of Crop Max @ 750 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_8) and which was on par with the foliar application of Crop Max @ 625 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_7) stage (11.35 dm^2 $plant^{-1}$,3.78 and 71.41 g $plant^{-1}$), respectively. This might be due to better availability of nutrients by the foliar nutrition of Crop Max which might have provided the required Mg^{+2} which has biochemical role in stimulation of photosynthesis, phloem export, root growth and nitrogen metabolism. It also impacts the N-fixation in pulses as it contains Mn^{+2}. Mn^{+2} is a constituent of abundant sources cation activated enzymes like decarboxylase, kinase, oxidase etc., and hence, vital for the formation of chlorophyll, reduction of nitrates. As the seaweeds also contain trace elements like Fe, Cu and Zn in considerable amount reduces redox reaction of respiration and photosynthesis, encourages reduction of No^{-3} and So^{-4} and boost-up the cation-activated enzyme respiration and transfer of photosynthates to growing sites and meristematic tissues helping in meristematic cell division and expansion that reflects positively in leaf area and leaf area index. These results are in line with the findings of Shyamrao *et al.* (2015) and vishwanatha *et al.* (2022) [24] in green gram. Higher dry matter accumulation might be due to higher leaf area and number of leaves resulting from higher light interception, maintaining chlorophyll content and higher photosynthesis ultimately leading to higher dry matter accumulation. The similar results were reported by Kuttimani and Velayutham (2011) [16], Kavipriya *et al.* (2011) [10], Singh (2013) [21], and Vishwanatha *et al.* (2022) [24].
Between 30-60 DAS highest AGR (2.062 g day^{-1}) and CGR (68.72 g m^{-2} day^{-1}) were recorded with the application of Crop Max @ 750 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_8) and was on par with the foliar application of Crop Max @ 625 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_7) stage (2.041 g day^{-1}) and (68.02 g m^{-2} day^{-1}), respectively, Significantly lower AGR (1.915 g day^{-1}) and CGR (5.57 g m^{-2} day^{-1}) and was witnessed with control-2 (T_{11}). Between 60 DAS to harvest, Application of Crop Max @ 750 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_8) resulted significantly higher AGR (0.211 g day^{-1}), CGR (7.02 g m^{-2} day^{-1}) and biomass duration (1239.7 g days $plant^{-1}$) significantly lowest AGR (0.167 g day^{-1}), CGR (5.57 g m^{-2} day^{-1}) and biomass duration (1143.6 g days $plant^{-1}$) was observed with control-2 (T_{11}). This might be due to higher leaf area by which the site available for photosynthesis is maximum and produced photosynthates are accumulated in the sink from source thus increasing in the dry matter production and accumulation which was recorded maximum after the foliar application of biostimulants at flowering stage and pod formation than application at earlier growth stages (vegetative stages) and continued till the harvest of the crop. These results are in line with the findings of Pramanick *et al.* (2013) [31], Pashuapthimath (2020) [17] and Vishwanath *et al.* (2022) [24]. Ertani *et al.* (2013) [7] also showed that differences in effects of biostimulants were due to the number of treatments at the appropriate BBCH stages. This proves that not only the concentrations but also the stage at which the spray must be taken up.
Foliar application of Crop Max @ 625 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_7) (81.4 days) recorded significantly higher leaf area duration. Significantly higher leaf area ratio (16 cm^2 g^{-1}) was observed with the foliar application of Crop Max @ 375 ml ha^{-1} at flower initiation followed by Biozyme @ 625 ml ha^{-1} at pod formation (T_5) and it remained on par with rest of the treatments except control-2. Significantly lower leaf area ratio (14.5 cm^2 g^{-1}) was recorded with control-2 (T_{11}) (Table 2). This might be due to the effective usage of the incident radiations which are involved in the photochemical reactions thus increasing the phytohormones and delay in the senescence because, biostimulants regulate the production of ethylene hormones in the leaves which might have helped in increasing the leaf area ratio and leaf area duration. These results are in line with the findings of Afifi *et al.* (2018) [1] and Pashuapthimath (2020) [17].
From the correlation and regression analysis it was verified that there is significant positive correlation between seed yield with growth parameters and growth indices such as leaf area (dm^2 $plant^{-1}$), leaf area ratio (cm^2 g^{-1}), leaf area duration (days), dry matter accumulation (g $plant^{-1}$), AGR (g day^{-1}), CGR (g m^{-2} day^{-1}), Biomass duration (g days $plant^{-1}$).
There is a significant rate of change of seed yield with every dm^2 $plant^{-1}$ change of leaf area, cm^2 g^{-1} change of leaf area ratio and days change of leaf area duration. R^2= 0.7865, 0.6191 and 0.6583 interprets that 78.56, 61.91 and 65.83 per cent leaf area, leaf area ratio and leaf area duration causes to the seed yield production, respectively with r=0.886, 0.843 and 0.7868 indicating high degree of positive correlation between leaf area, leaf area ratio and leaf area duration, respectively with seed yield.
There is a significant rate of change of seed yield with every g $plant^{-1}$ change of dry matter accumulation at 60 DAS and at harvest. R^2=0.9134 and 0.9312 interprets that 91.34 and 93.12

per cent dry matter accumulation causes to the seed yield production with r=0.956 and 0.965 indicating high degree of positive correlation between dry matter accumulation with seed yield, respectively.

There is a significant rate of change of seed yield with every g day^{-1} and g m^{-2} day^{-1} change of AGR and CGR at 60 DAS and at harvest. R^2=0.8994, 0.8501 and R^2=0.8994, 0.8501 interprets that 89.94, 85.01 and 89.94, 85.01 per cent AGR and CGR at 60 DAS and at harvest, respectively causes to the seed yield production with r=0.948, 0.9.22 and r=0.948, 0.922 indicating high degree of positive correlation of AGR and CGR with seed yield, respectively.

There is a significant rate of change of seed yield with every g days plant^{-1} change of biomass duration. R^2=0.914 interprets that 91.4 per cent biomass duration causes to the seed yield production with r=0.956 indicating high degree of positive correlation between biomass duration and seed yield, respectively.

Table 1: Leaf area, Leaf Area Index, dry matter accumulation and absolute growth rate of soybean as influenced by biostimulants

Treatment		Leaf area (dm^2 plant^{-1}) (60 DAS)	LAI (60 DAS)	Dry matter accumulation (g plant^{-1})		AGR (g day^{-1})	
				60 DAS	At harvest	30-60 DAS	60 DAS-harvest
T_1	Crop Max @ 375 ml ha^{-1} followed by Crop Max @ 375 ml ha^{-1}	10.33^{d}	3.44^{d}	68.43^{cd}	75.99^{cd}	1.967^{bc}	0.189^{a-c}
T_2	Crop Max @ 500 ml ha^{-1} followed by Crop Max @ 500 ml ha^{-1}	10.38^{d}	3.46^{d}	68.88^{b-d}	76.45^{b-d}	1.972^{bc}	0.189^{a-c}
T_3	Crop Max @ 625 ml ha^{-1} followed by Crop Max @ 625 ml ha^{-1}	10.68^{cd}	3.65^{bc}	69.48^{bc}	77.06^{b-d}	1.985^{bc}	0.189^{a-c}
T_4	Crop Max @ 750 ml ha^{-1} followed by Crop Max @ 750 ml ha^{-1}	11.33^{ab}	3.78^{ab}	71.31^{ab}	79.16^{a-c}	2.04^{ab}	0.196^{ab}
T_5	Crop Max @ 375 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	11.20^{ab}	3.73^{ab}	69.96^{a-c}	77.58^{a-c}	1.996^{ab}	0.190^{a-c}
T_6	Crop Max @ 500 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	11.28^{ab}	3.76^{ab}	71.21^{ab}	78.85^{a-c}	2.038^{ab}	0.191^{a-c}
T_7	Crop Max @ 625 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	11.35^{ab}	3.78^{ab}	71.41^{ab}	79.69^{ab}	2.041^{ab}	0.207^{ab}
T_8	Crop Max @ 750 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	11.47^{a}	3.82^{a}	72.25^{a}	80.68^{a}	2.062^{a}	0.211^{a}
T_9	Biozyme @ 625 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	10.31^{d}	3.44^{d}	68.35^{cd}	75.71^{cd}	1.965^{bc}	0.184^{bc}
T_{10}	Control-1 (Urea @ 2% and KNO_3 @ 1%)	10.96^{bc}	3.56^{cd}	69.54^{bc}	77.10^{bc}	1.985^{bc}	0.189^{a-c}
T_{11}	Control-2 (water spray)	9.7^{e}	3.23^{e}	66.85^{d}	73.53^{d}	1.915^{c}	0.167^{c}
S.Em. ±		0.14	0.05	0.8	1.0	0.02	0.007

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P=0.05) DAS- Days after sowing

Note 1. RDF: FYM @ 6.25 t + 40:80:25 kg N: P_2O_5 and K_2O + $ZnSO_4$ @ 12.5 kg + *Rhizobium* and PSB @ 1250 g each per hectare common to all treatments

Note 2. For T_1 to T_{10}, foliar application at flower initiation (25-35DAS) and at pod formation stage (45 – 50 DAS).

Table 2: Crop Growth Rate, Biomass Duration, Leaf Area Duration and Leaf Area Ratio of soybean as influenced by biostimulants

Treatment		CGR (g m^{-2} day^{-1})		Biomass duration (g days plant^{-1})	Leaf area duration	Leaf area ratio (cm^2 g^{-1})
		30-60 DAS	60 DAS-harvest	30-60 DAS	days	60 DAS
T_1	Crop Max @ 375 ml ha^{-1} followed by Crop Max @ 375 ml ha^{-1}	65.56^{bc}	6.30^{a-c}	1167.8^{cd}	75.8^{ab}	15.1^{a-c}
T_2	Crop Max @ 500 ml ha^{-1} followed by Crop Max @ 500 ml ha^{-1}	65.74^{bc}	6.30^{a-c}	1179.0^{cd}	73^{b}	15.0^{bc}
T_3	Crop Max @ 625 ml ha^{-1} followed by Crop Max @ 625 ml ha^{-1}	66.15^{bc}	6.31^{a-c}	1191.4^{bc}	80.5^{a}	15.3^{a-c}
T_4	Crop Max @ 750 ml ha^{-1} followed by Crop Max @ 750 ml ha^{-1}	67.99^{ab}	6.53^{ab}	1221.5^{ab}	81.1^{a}	15.8^{ab}
T_5	Crop Max @ 375 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	66.53^{ab}	6.34^{a-c}	1200.7^{bc}	78.4^{ab}	16.0^{a}
T_6	Crop Max @ 500 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	67.92^{ab}	6.36^{a-c}	1219.5^{ab}	78.9^{ab}	15.8^{ab}
T_7	Crop Max @ 625 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	68.02^{ab}	6.90^{ab}	1224.1^{ab}	81.3^{a}	15.8^{ab}
T_8	Crop Max @ 750 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	68.72^{a}	7.02^{a}	1239.7^{a}	80.7^{a}	15.8^{ab}
T_9	Biozyme @ 625 ml ha^{-1} followed by Biozyme @ 625 ml ha^{-1}	65.49^{bc}	6.14^{bc}	1166.3^{cd}	75.9^{ab}	15.1^{abc}
T_{10}	Control-1 (Urea @ 2% and KNO_3 @ 1%)	66.17^{bc}	6.30^{a-c}	1192.3^{bc}	76.3^{ab}	15.7^{ab}
T_{11}	Control-2 (water spray)	63.84^{c}	5.57^{c}	1143.6^{d}	73.1^{b}	14.5^{c}
S.Em. ±		0.76	0.24	12	1.8	0.3

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P=0.05) DAS- Days after sowing

Note 1. RDF: FYM @ 6.25 t + 40:80:25 kg N: P_2O_5 and K_2O + $ZnSO_4$ @ 12.5 kg + *Rhizobium* and PSB @ 1250 g each per hectare common to all treatments

Note 2. For T_1 to T_{10}, foliar application at flower initiation (25-35DAS) and at pod formation stage (45 – 50 DAS)

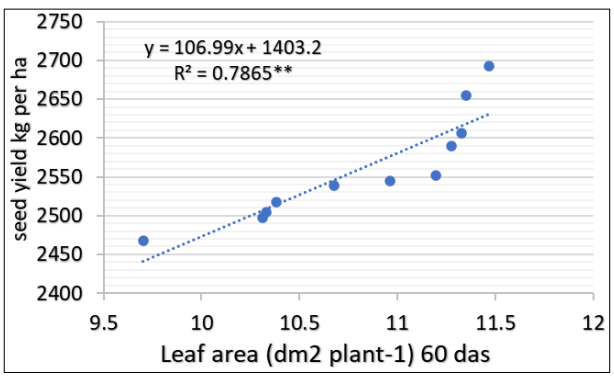

Fig 1: Linear regression graph indicating raise of yield in accordance with leaf area (r= 0.886)

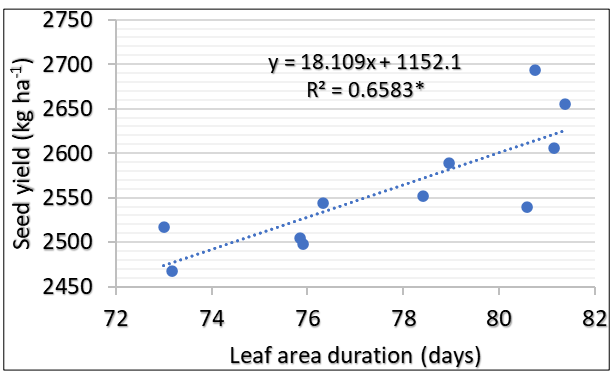

Fig 2: Linear regression graph indicating raise of seed yield in accordance with leaf area duration (days) (r= 0.81134)

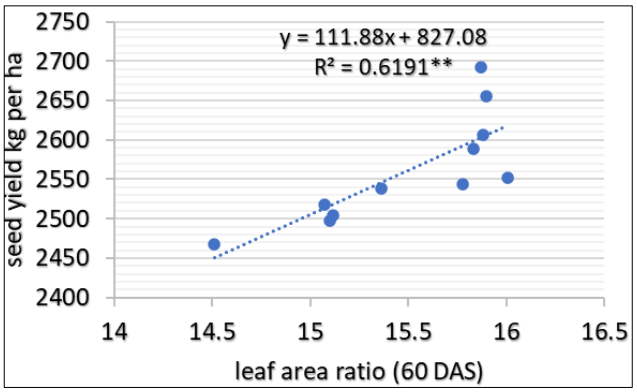

Fig 3: Linear regression graph indicating raise of yield in accordance with leaf area ratio (r= 0.786845)

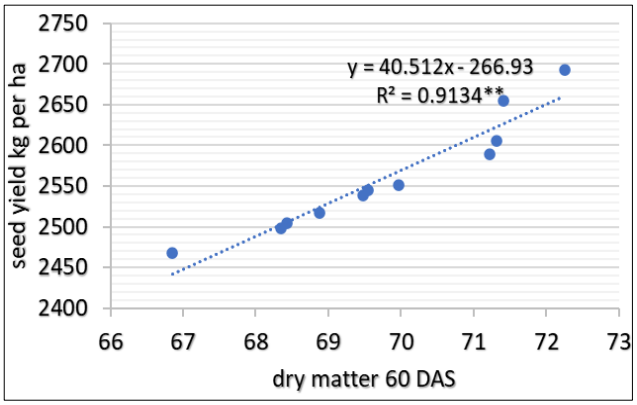

Fig 4: Linear regression graph indicating raise of yield in accordance with dry matter accumulation at 60 DAS (r= 0. 0.956)

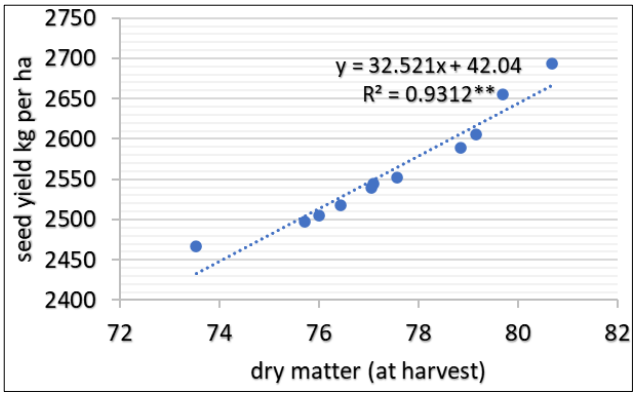

Fig 5: Linear regression graph indicating raise of yield in accordance with dry matter accumulation at 60 DAS (r= 0.965)

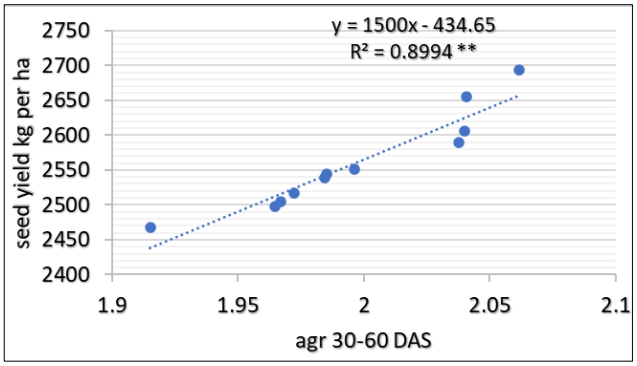

Fig 6: Linear regression graph indicating raise of yield in accordance with AGR between 30-60 DAS (r= 0.94835)

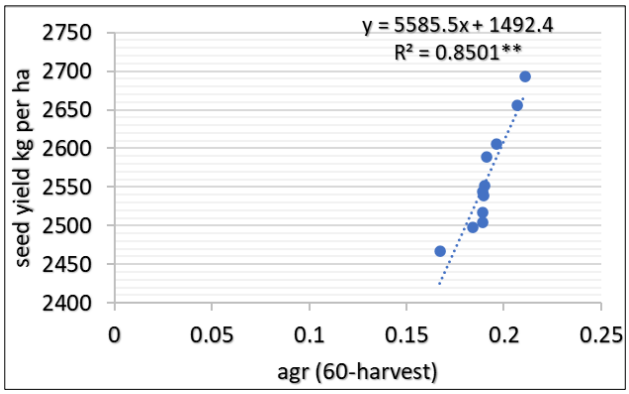

Fig 7: Linear regression graph indicating raise of yield in accordance with AGR between 60 DAS-harvest (r= 0.922)

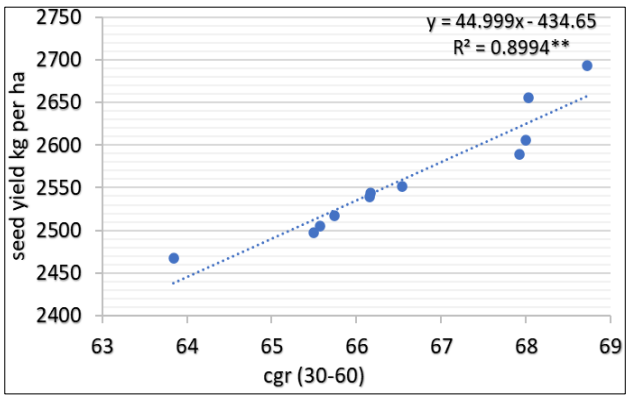

Fig 8: Linear regression graph indicating raise of yield in accordance with CGR between 60 DAS-harvest (r= 0.948)

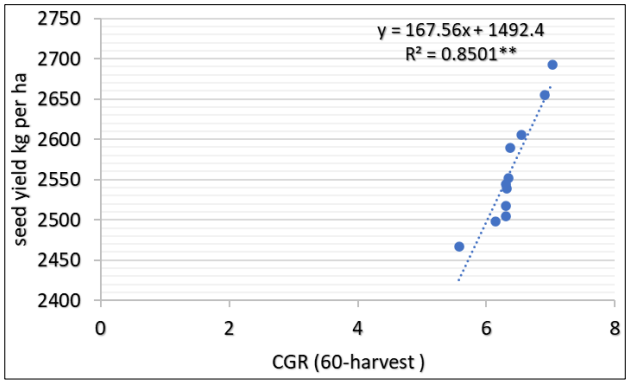

Fig 9: Linear regression graph indicating raise of yield in accordance with CGR between 60 DAS-harvest (r= 0. 922)

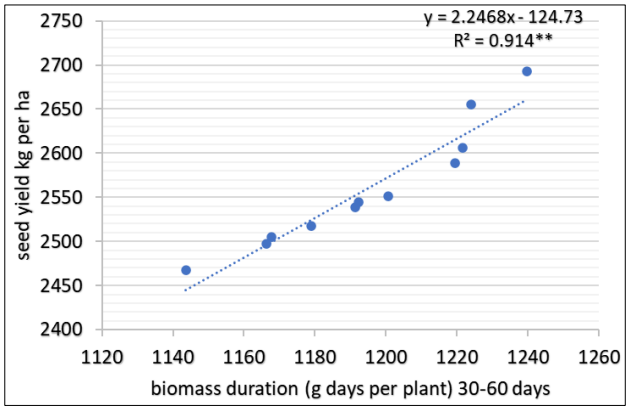

Fig 10: Linear regression graph indicating raise of yield in accordance with biomass duration (r= 0.956)

Conclusion

It is interpreted from the current study that use of Crop Max as a biostimulant @ 750 ml ha^{-1} followed by Biozyme has a significant influence on the growth parameters and growth indices, significant correlation between growth parameters, growth indices and yield. There is a positive and significant correlation and high degree of relation between growth parameters/indices with the seed yield.

References

1. Afifi ST, Shalata AAA, Kiera RM. Effect of compost rates and spraying with some biostimulant substances on growth, yield and quality of snap bean. Journal of Plant Production. 2018;9(7):601-607.
2. Anjum SA, Wang L, Farooq M, Xue L, Ali S. Fulvic acid application improves the maize performance under well-watered and drought conditions. Journal of agronomy and crop science. 2011;197(6):409-417.
3. Avornyo VK, Manu A, Adu-Gyamfi R. Response of soybean (*Glycine max* (L.) Merr) to PS-Foundation 1-0-1 biostimulant, triple super phosphate, and rhizobium inoculant. Communications in Soil Science and Plant Analysis. 2020;51(7):985-996.
4. Aydm A, Turan M, Sezen Y. Effect of fulvic+ humic acid application on yield and nutrient uptake in sunflower (*Helianthus annuus*) and corn (*Zea mays*). Improved Crop Quality by Nutrient Management; c1999. p. 249-252.
5. Delfine S, Tognetti R, Desiderio E, Alvino A. Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agronomy for sustainable Development. 2005;25(2):183-191.
6. Ed. Sestak Z, Catasky J, Jarvis PG. Plant photosynthetic production manual of methods, Dr. Junk W. N. V, Publication, The Hague, Netherlands; c1971. p. 343-354.
7. Ertani A, Pizzeghello D, Altissimo A, Nardi S. Use of meat hydrolyzate derived from tanning residues as plant biostimulant for hydroponically grown maize. Journal of Plant Nutrition and Soil Science. 2013;176(2):287-295.
8. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley & Sons; c1984.
9. Huang T, Jander G, de Vos M. Non-protein amino acids in plant defence against insect herbivores: representative cases and opportunities for further functional analysis. Phytochemistry. 2011;72(13):1531-1537.
10. Kavipriya R, Dhanalakshmi PK, Jayashree S, Thangaraju N. Seaweed extract as a biostimulant for legume crop, green gram. Journal of Eco-biotechnology. 2011;3(8):16-19.
11. Kavitha MP, Ganesaraja V, Paulpandi VK. Effect of foliar spraying of sea weed extract on growth and yield of rice (*Oryza sativa* L.). Agricultural Science Digest. 2008;28(2):127-129.
12. Kocira S. Effect of amino acid biostimulant on the yield and nutraceutical potential of soybean. Chilean journal of agricultural research. 2019;79(1):17-25.
13. Kocira S, Szparaga A, Kuboń M, Czerwińska E, Piskier T. Morphological and biochemical responses of *Glycine max* (L.) Merr. to the use of seaweed extract. Agronomy. 2019;9(2):93.
14. Kulkarni S, Upperi SN, Jadhav RL. Greengram productivity enhancement through foliar spray of nutrients. Legume Research-An International Journal. 2016;39(5):814-816.
15. Kumawat RN, Mahla HR. Effect of foliar applied urea and planting pattern on the leaf pigments and yield of cluster bean (*Cyamopsis tetragonoloba* L.) grown in low rainfall areas of western India. Legume Research-An International Journal. 2015;38(1):96-100.
16. Kuttimani R, Velayutham A. Foliar application of nutrients and growth regulators on yield and economics of greengram. Madras Agricultural Journal. 2011;98(4-6):141-143.
17. Pashupatimath SS. Effect of soil and foliar application of humic substances as a biostimulants on biomass, nutrient uptake and quality of soybean [*Glycine max* (L.) Merrill.]. M.Sc. (Agri.) Thesis, University of Agricultural and Horticultural Sciences, Shimoga, Karnataka; c2020.
18. Power JF, Willis WO, Reichman GA. Effect of soil temperature, P and plant age on growth analysis of barley. Agronomy Journal. 1967;18:459-463.
19. Radford PG. Growth analysis formulae their use and abuse. Crop science. 1967;7:171-175.
20. Rehman H, Alharby HF, Alzahrani Y, Rady MM. Magnesium and organic biostimulant integrative application induces physiological and biochemical changes in sunflower plants and its harvested progeny on sandy soil. Plant Physiology and Biochemistry. 2018;126:97-105.
21. Singh AK. Efficacy of seaweed sap on productivity of soybean M.Sc. (Agri) Thesis, Birsa Agricultural University Ranchi, Jharkhand; c2013.
22. Szparaga A, Kocira S, Kocira A, Czerwińska E, Świeca M, Lorencowicz E, *et al*., Modification of growth, yield, and the nutraceutical and antioxidative potential of soybean through the use of synthetic biostimulants. Frontiers in Plant Science. 2018;9:1401.
23. Tahir MM, Khurshid M, Khan MZ, Abbasi MK, Kazmi MH. Lignite-derived humic acid effect on growth of wheat plants in different soils. Pedosphere. 2011;21(1):124-131.
24. Vishwanatha S, Shwetha BN, Koppalkar BG, Ashoka N, Ananda N, Umesh MR, *et al*., Response of black gram (*Vigna mungo* L.) and soybean (*Glycine max* L.) to novel bio stimulants in northeastern dry zone of Karnataka. Legume Research-An International Journal. 2022;45(9):1130-1136.
25. Kocira A, Świeca M, Kocira S, Złotek U, Jakubczyk A. Enhancement of yield, nutritional and nutraceutical properties of two common bean cultivars following the application of seaweed extract (*Ecklonia maxima*). Saudi journal of biological sciences. 2018 Mar 1;25(3):563-71.
26. Pashupatimath SG, Madhavanavar S. Different techniques used in traffic control system: An introduction. Int. J Eng. Res. Technol. 2018;6(03):1-4.
27. Singh J, Steele K, Singh L. Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. Journal of Educational Technology Systems. 2021 Dec;50(2):140-71.
28. Calvo P, Nelson L, Kloepper JW. Agricultural uses of plant biostimulants. Plant and soil. 2014 Oct;383:3-41.
29. Vasconcelos MC, Greven M, Winefield CS, Trought MC, Raw V. The flowering process of *Vitis vinifera*: a review. American Journal of Enology and Viticulture. 2009 Dec 1;60(4):411-34.

30. Sharma L, Markon KE, Clark LA. Toward a theory of distinct types of impulsive behaviors: a meta-analysis of self-report and behavioral measures. Psychological bulletin. 2014 Mar;140(2):374.
31. Pramanick B, Brahmachari K, Ghosh A. Effect of seaweed saps on growth and yield improvement of green gram. African Journal of Agricultural Research. 2013;8(13):1180-6.