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Effect of plant growth regulators on yield attributes and productivity of mungbean (*Vigna radiata* L. Wilczek)

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Abstract
Plant growth regulator plays an important role of crops yield especially in mungbean. Therefore, an experiment was conducted in cement-moulded pots inside the net house to find out the effect of plant growth regulators viz. Maleic Hydrazide, Gibberellin, Triacontanol, 2,3,5-triiodobenzoic acid and Cycocel, as foliar spray. The result indicated significant variations in number of flowers plant^{-1}, pod setting, seeds per pod, pod length and 100 seed weight due to plant growth regulators. The result obtained from the study concluded that productivity and number of pod per plant was highest in case 40 ppm TIBA among all the treatment although seed weight was found highest in GA 40 ppm. These results might suggest that use of plant growth regulator might improve yield of mung bean. Gibberellic acid (GA3) as a plant growth promoter affects plant growth and development by promoting metabolic activities and regulating nitrogen utilization.

Keywords: Yield attributes, *Vigna radiata* L. Wilczek

Introduction
The high protein content in pulses in comparison to cereal make pulses an important part of nutrition in many parts of the world. Its vitamin B, minerals and dietary fibers content cannot be neglected as important constituent of nutrition. Their natural ability to fix atmospheric nitrogen into the soil makes it a preferred candidate for crop rotation with non-legume crops in *Rabi* (South India), *Kharif* and *Zaid* seasons. Mungbean has been the most preferred pulse due to its easy digestibility. Productivity of mungbean have remained static in recent and there has been a widening gap between supply and demand (Gowda *et al.*, 2013). Area under mung bean cultivation in India is 3.02 m ha with a production of 1.50 m tones and productivity 298.0 kg/h. In U.P., it occupies 88.0 ha area with production of 46.0 tones and productivity 523.0 kg/h. Physiological efficiency of plants are effected by plant growth regulators in positive and negative directions. Its effect is known to promote vegetative growth and certain yield attributes such as flower and fruit set. TIBA (2, 3, 5-triiodo benzoic acid), a synthetic growth regulator is used for checking the excessive vegetative growth and lodging tendency, reducing the abscission of flowers and immature pods and for modification of crop canopy to improve the productivity of crops (Adam and Jahan 2014) [1]. Cycocel is known at sufficient concentration to counteract the effect of indigenous ABA and reduce the percentage of shedding (Singh *et al*., 2017). Other bio-regulators as TRIA has been reported to have profound effect on increasing the seed weight. These regulations of certain characteristics in plants by these bio-regulators remains poorly explored and little underlying knowledge has been realised. It is therefore considered imperative to study the effect of plant growth regulators on mungbean with following aims as effect of PGRs on growth, yield attributes in mungbean due to PGRs.

Material and methods
Variety "Samrat" was procured from the Research cum seed production farm CSAUAT, Kanpur. Experimental units used were cemented of pots 25 cm^2 filled with 8 Kg of soil each. The bottom holes were covered with pieces of broken pot well pulverized and air dried soil was filled in the pots and compacted after filling. The fertilizers were applied @15 Kg N. 40 Kg P_2O_2/ha as per recommendation in the split doses, half quantity basal and another half as top dressing. The experiment was laid out in Complete Randomized Design (CRD).

Preparation of solutions and spraying

The calculated amount of each bio regulator i.e. MH, GA, TRIA, CCC, TIBA at different doses, were weighed on chemical balance. Except CCC, all were first dissolve in few drop of ethyl alcohol stirring well, made a paste and then made up the volume upto 1000 ml with distilled water separately, Kept all the solutions it in well stoppered flat bottom flask of capacity 1 litre ready before use. Solutions added with adhesive tween 20 @ 0.1%. Control pots were treated with distilled water along with Tween-20. The treatments are sprayed using a hand held atomizer sprayer.

Detail of treatment

Each of the plant growth regulator were prepared into two concentrations, i.e. ten (10) treatments, one control namely, Maleic Hydrazide (50 ppm and 100 ppm), Gibberellin (20 ppm and 40 ppm) Triacontanol (2 ppm and 4 ppm), Cycocel (50 ppm and 100 ppm), 2,3,5-triiodobenzoic acid (20 and 40 ppm) Control (distilled water) into four replications each treatments were delivered through foliar spray at 30 and 45 days after sowing.

Yield parameters

Yield parameters including numbers of pods per plant, numbers of seed per pod, seed yield per plant, 100 seed weight were manually counted and recorded. The number of flowers were counted from the start of flowering to the end, during which the prematurely shed of flower numbers were recorded.

Net assimilation rate

Net assimilation rate (NAR) was calculated by using the formula

$$\text{NAR}=\frac{W_2 - W_1}{t_2 - t_1}\times\frac{\log_e LA_2 - \log_e LA_1}{LA_2 - LA_1}\ \text{gm}^{-2}\ \text{day}^{-1}$$

Where, W_2 and W_1 are the final and initial dry weights of aerial plant parts per unit area at the times t_1 and t_2, respectively, and LA_2 and LA_1 are the final and initial leaf area indices at respective times.

Harvest index

Harvest index percentage was calculated by using the formula

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield}}{\text{Biological Yield}}\times 100$$

Results and discussions

Floral initiation number of flowers per plant and flower shedding

Pertaining to the data represented in (Table no. 1.) plant growth regulators treatments exhibited significant effect of minimum days required for floral initiation with GA 40 ppm being shortest to have achieved floral initiation whereas, TIBA 400 ppm recorded the highest number of flowers. Floral maturity was found to be delayed highest due to application of TIBA 40 ppm at 87 DAS closely followed by CCC 100 ppm over the control. Treatments of MH were found to slightly hastened maturity. Minimum number of flowers per plant was recorded by the treatment of MH-50 ppm. TIBA was found to increase flower numbers as reported by A. (Sumathi *et al*., 2016) [12], maximum production of flowers per plant was found by the application of TIBA 40ppm closely followed by TIBA 20ppm as (Castro and Moroes 1981).

Percent of pod setting per plant

All the growth regulators application significantly influenced the extent of pod setting percentage per plant in comparison to control. Maximum pod setting percentage was recorded by the application of GA treatments closely followed by TIBA 40ppm and TIBA 20 ppm sequentially.

Number of pods per plant and pod length

Number of pods per plant significantly varied against of pods in control pots. All growth regulators treatment significantly increased the number of pods per plant in comparison to control. Maximum number of pods per plant obtained by the treatment of TIBA 40 ppm closely followed by TIBA 20 ppm, CCC 50 ppm and CCC 100 ppm, as suggested by Yadav, M. S., & Dhanai, C. S. (2016) whereas control gave least position in this regard. (Table 1)

Treatment of plant growth regulators has been found to positively correlate to the pod length and has been found to increase the pod length. Of all treatments GA 40 ppm is found to maximally increase pod length following which is in conformity with Hoque, M., & Haque, S. (2002) [6], minimum length recorded by the control preceded by TIBA 40 ppm and TIBA 20 ppm. (Table 1)

Seed yield per pod and Seed yield per plant

A critical examination of seed yield data displayed in the (Table 1) revealed that spraying of growth regulators on mung bean plant produced significantly more seed yield over control plants. Maximum seed yield per plant was recorded by the treatment of TIBA-40ppm followed by TIBA-20ppm, closely followed by CCC-50 ppm and CCC-100 ppm as reported by (Kumar. P. *et al*., 2002) [8]

100 Seed Weight

Different growth regulators treatments significantly increased the test weight over the control. The maximum test weight was obtained with GA-40 ppm followed by MH 50 ppm and GA 20 ppm, whereas TRIA 2 ppm and TRIA 4 ppm yielded minimum response among all treatments and corresponds to the concentration. All the treatments were found to significantly increase test weight, TIBA and TRIA showed minimum increased test weight with respect to control. (Table. 2).

Harvest Index

Persual of data present in (Table 2) imparted image that maximum harvest index was recorded with CCC-50 ppm closely followed by CCC 100ppm and GA 40ppm whereas MH 100 ppm gave least position in this regard.

Table 1: Effect of plant growth regulators on flower shedding, pod setting, pod length, number of seeds pod^{-1}, Number of pods.

Treatment in ppm		Flower shedding (%)	Pod Setting (%)	Pod length in cm	Number of pods (plant^{-1})	Number of seeds (pod^{-1})
Maleic Hydrazide	50 ppm	36.8	64.6	5.9	30	6.8
	100 ppm	36.9	66.3	6.2	44	6.7
Gibberellin	20 ppm	34.7	77.4	6.5	35	6.9
	40 ppm	36.2	79.4	6.7	42	6.8
Triacontanol	2ppm	30.3	61.5	6.2	30	6.7
	4 ppm	23.5	75.7	6.2	44	6.7
Cycocel	50 ppm	24.4	75.6	6.2	40	7.4
	100 ppm	26.2	73.8	6.3	31	7.3
2,3,5 -Triiodobenzoic	20 ppm	24.2	75.8	5.9	41	7.8
Acid	40 ppm	22.8	77.2	5.8	47	7.9
Control	water	41.7	58.3	5.2	26	6.5
S.Ed (±)		0.869	2.393	0.083	0.089	1.515
C.D. (5%)		1.772	4.871	0.159	0.153	2.555

Biological yield per plant

Pertaining to the data the highest biological yield was found to be highest at TIBA 20 ppm closely followed by TIBA 40 ppm, CCC 100 ppm, CCC 50 ppm.

Productivity

Pertaining to the data the highest productivity was found to be for treatment TIBA 40 ppm closely followed by 20 ppm. TIBA was at par with the productivity of CCC. MH 50 ppm productivity was insignificant to the productivity of the control. GA was significant to the control but was at par to that of MH 100 ppm, TRIA 2ppm, TRIA 4 ppm.

Table 2: Effects of plant growth regulators on seed yield plant, biological yield plant, 100 seed weight, H.I., Productivity.

Treatment in ppm		Seed yield plant^{-1} in (g.)	100 seed weight (g.)	Biological yield plant^{-1} (g.)	H.I. (%)	Productivity g^{-1}day^{-1} plant^{-1}
Maleic Hydrazide	50 ppm	5.56	2.92	36.13	24.56	0.082
	100 ppm	6.8	2.85	36.65	25.21	0.085
Gibberellin	20 ppm	6.72	2.88	36.93	25.62	0.084
	40 ppm	6.9	3.02	36.43	26.06	0.086
Triacontanol	2ppm	6.89	2.56	36.16	25.84	0.086
	4 ppm	6.76	2.59	37.75	24.14	0.084
Cycocel	50 ppm	6.7	2.79	38.44	26.26	0.083
	100 ppm	7.89	2.75	38.64	27.04	0.093
2,3,5 -Triiodobenzoic	20 ppm	7.95	2.66	39.57	26.96	0.091
acid	40 ppm	7.47	2.62	39.40	25.55	0.098
Control	Water	7.32	2.42	22.63	26.68	0.099
S.Ed (±)		0.316	0.063	0.983	0.441	0.0077
C.D. (5%)		0.654	0.127	2.003	0.895	0.0157

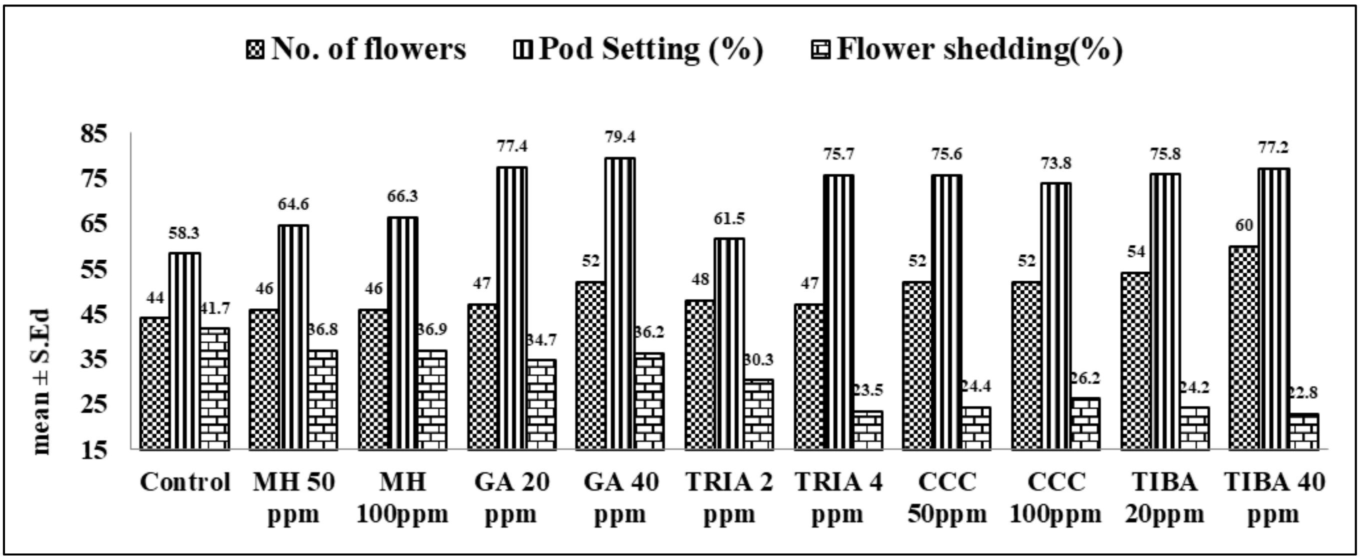

Fig 1: Effect of plant growth regulators on Number of flowers, pod setting, and flower shedding. Data presented are means ± S.Ed (Vertical bars)

Net assimilation rate

Different growth regulators considerably influence the relative growth rate value per plant at all stages of growth (Fig. 2). Maximum increased in net assimilation rate was recorded under the treatment of GA 40 ppm followed by 20 ppm, CCC 100 ppm between 40 DAS and 50 DAS stages.

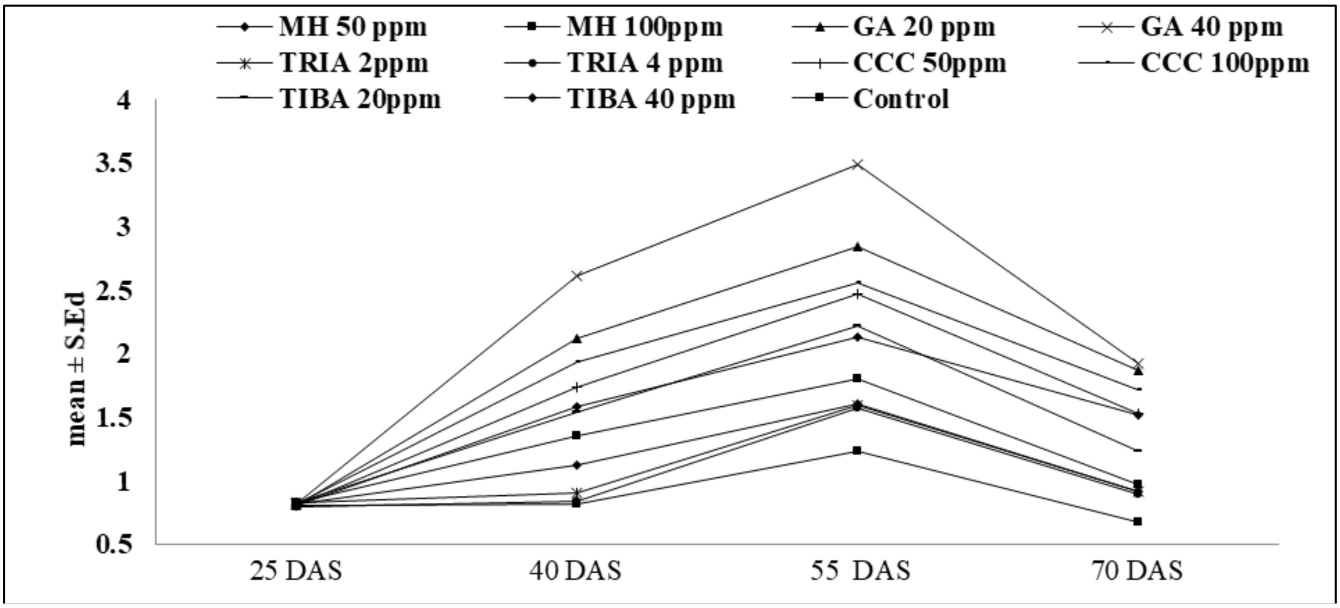

Fig 2: Effect of plant growth regulators on Net Assimilation Rate. Data presented are means ± S. Ed

At between 50 DAS and 60 DAS stages, minimum net assimilation rate value was obtained by the treatment of control closely followed by GA-20ppm.TIBA treatments closely follows the maximum net assimilating CCC treatments. Higher doses positive correlated with the higher doses.

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