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Effect of foliar application of plant growth regulators on growth and development, biochemical changes and yield of mung bean (*Vigna radiata* L.)

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Abstract
A experiment was carried out under field condition at Students Instructional Farm of Acharaya Narendra Deva University of Agriculture & Technology, Narendra Nagar, (Kumarganj), Ayodhya U.P. during *kharif* season 2019 based on a Randomized Blok Design with three replications, variety Narendra Mung-1 with seven treatments were taken. The foliar sprayed of GA_3 75 ppm was found most effective for increasing the plant height, number of branches per plant(7.50), total dry biomass per plant (29.75 g) and chlorophyll content SPAD value (10.28), protein content in seed (24.63%), number of pod per clusters (7.39), number of pods per plant (48.92), pod length (8.92 cm), number of seeds per pod (9.21), number of seeds per plant (455.33), 100 seed weight (3.62 g), seed yield per plant (15.07g), followed by foliar sprayed of NAA 150 ppm over rest of the treatments. Generally, the use of growth regulators as foliar application increased the yield and yield components.

Keywords: Mungbean, GA_3, chlorophyll content, physiological, NAA, salicylic acid

Introduction
Mung bean is botanically recognized as *Vigna radiata* Lin. Wilczek and belongs to the family *Fabaceae* (*leguminaceae*). The genus *Vigna* has been broadened to include about 155 species but only twenty-two species are native to India. Where they are grown in large numbers and are often grouped under distinct varieties and sub species. One of the most important among these species is *Vigna radiata* with dark-green foliage, spreading pods and green seeds. Green gram is the third most important pulse crop in India. (Anonymous 2004) [3]. It has high nutritive value and due to this, has advantage over the other pulses. The seed contains 24.20% protein content, 1.30% fat, and 60.4% carbohydrates, calcium (Ca) 118 and phosphorus (P) is 340 mg per 100 g of seed, respectively (Imran *et al*., 2016).
In India, pulses are grown over an area of 29.28 mha with a production and productivity of about 22.40 m tonnes and 765 kg/ha, respectively. This covers about 20% of total area and 8% of total grain production in India. India has largest area and production of pulses in the world. All over India, total pulse production was recorded about 23.95 million tonnes in (2017-18)
Naphthalene acetic acid is a synthetic plant hormone in the auxin family and is an ingredient in many commercial plant rooting horticultural product, it is a rooting agent and used for the vegetative propagation of plants from stem and leaf cutting. Naphthalene acetic acid has been shown to greatly increase cellulose fiber formation in plants when paired with another phytohormone called gibberellic acid. Because it is in the auxin family it has also been understood to prevent premature dropping and thinning of fruits from stems.
Gibberellic acid may play an important role as this is known to affect many facets of plant life, including, seed germination, leaf expansion, N-fixation, phloem loading, water and mineral uptake, assimilate translocation, harvest index. Gibberellic acid occupies a prominent position in mediating a variety of plant physiological processes including seed germination, leaf expansion, flower and fruit set, dry matter production, photosynthesis, translocation of food material and synthesis of mRNA coding for hydrolytic enzymes. (Mohd Mazid 2014) [12].

Materials and Methods
The field experiments were carried out during *kharif* seasons of 2019 in Students instructional Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, (Kumarganj), Ayodhya. Solution of GA_3 25 ppm, GA_3 50 ppm, $GA_3$75 ppm, NAA 50 ppm, NAA (100 ppm) and NAA (150 ppm) were prepared.

Foliar applications done at 20 days after sowing with the help of hand sprayer as per treatment. While in untreated control distilled water was sprayed. The experiment was planned with randomized block design in three replications morpho-physiological parameter were taken, germination (%) = **(**number of seeds germinated/total number of seeds) x100, plant height (20, 40, 60 DAS and at maturity), dry weight per plant**,** days to maturity, chlorophyll and nitrogen content (SPAD meter, Model: X55/M-PEA),

Harvest Index (%) = [(Economic yield)/(Biological Yield)] ×100.

Isolation of protein content in seed

The soluble and insoluble protein content was estimated by using method of Lowery *et al.* 1951. The final colour is the result of biuret reaction of the protein with copper ion in alkaline medium and reaction of phosphomalybdic turgustic reagent by the tyrosine and tryptophan present in the treated protein. Reagent: (A) 2% $Na_2 CO_3$ in 0.1 N NaOH. (B) 0.5% $CuSO_4$, $5H_2O$ in 1% sodium potassium tartarte. (C) Alkaline copper solution mix 50 ml of reagent A with reagent B, (Discarded after day). (D) Carbonate copper solution, is the same as C expect for omissions of NaOH. (E) Diluted folin reagent. Extraction**:** First of all crushed the seed in powdery form and moist with 80% ethanol and centrifuged at 4000 rpm for 20 minutes. The residue left after 80% ethanol extraction was hydrolyzed in 5.0 ml of 0.3 NaOH for one hour and then centrifuged. Both the supernatants were pooled and the volume was made to 10 ml. Procedure**:** 0.5 ml aliquot was taken in test tube and mixed with 5 ml of reagent C allowed to stand for 10 minutes. Thereafter, 0.5 ml of reagent D was add with instant mixing after 30 minutes, OD was measured at 750 nm.

Statistical Analysis

Data recorded on various growth and yield attributes were subjected to statistical analysis by Fisher method of analysis of variance (Fisher and Yates 1949).

Result and Discussion

Morphological parameter

The growth parameters of mung bean like plant height, number of branches per plant and total dry biomass per plant have been influenced by foliar spray of various plant growth regulators at various stages of crop growth. The maximum plant height (18.53, 40.34, 56.33, 65.29 at harvest) respectively was recorded with foliar spray of GA_3 75ppm as compared to control at all the stages of crop growth (30, 45, 60, DAS and at harvest stages). The higher plant height was measured with foliar application of GA_3 75 ppm and NAA 150 ppm which found more pronounced and both treatments registered significant increase in plant height as compared to untreated control at all the stages of observations, which might be due to enhanced stem elongation because of application of plant growth regulators particularly GA_3 contributed a lot in affecting plant height of mung bean. These results are agreement with Bahaa and El-Din Mekki (2016) [4] studies that application of 100 ppm GA_3 significantly increase plant height of mungbean., These findings was according with Kumar *et al.* (2017) foliar spray of GA_3 at 150 ppm showed increased plant height followed by salicylic acid 100 in ppm china aster (*Callistephus chinensis* L.) The maximum number of branches per plant (4.21, 6.43, 7.50) were recorded with foliar spray of GA_3 75ppm as compared to control at all the stages of crop growth (45, 60, DAS and at harvest) followed by NAA and control. The present investigation is also support by Hoque *et al*. (2002). The maximum increase in total dry biomass (7.28, 8.75, 17.92, 29.75 g per plant) was observed with foliar spray of GA_3 75ppm at 30, 45, 60 DAS and at harvest stage. The higher total dry biomass was found with foliar spray of GA_3 75ppm and registered significant increase in the dry biomass per plant as compared to untreated control at 30, 45, 60 DAS and at harvest stage of crop which might be due to stem elongation, increase in cell size of leaves and another possible growth factors as influenced by GA_3 application. The increase in plant dry biomass due to foliar spray treatments indicated that the photosynthetic activity and affiance of the leaves have been increased which contributed to dry biomass production. Similar finding have been reported by Ibrahim *et al*. (2007) [7]. reported the response of sweet basil (*Ocimum basilicum* L.) and Kalyankar *et al*. (2008) [10] showed that foliar spray of GA_3 (150ppm) increased number of leaves and leaf area. NAA (150ppm) was effective in increasing total dry biomass.

Table 1: Effect of plant growth regulators on plant height, number of branches per plant and total dry biomass per plant of mung bean during *kharif season*

Treatments	Plant height (cm)				Number of branches per plant			Total dry biomass per plant (g)			
	30 DAS	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest
Control	12.04	28.29	43.75	47.17	1.83	3.02	3.73	4.15	5.60	14.43	23.56
GA_3 (25ppm)	14.44	32.52	48.25	53.34	2.21	3.92	4.14	5.78	7.62	16.44	26.87
GA_3 (50ppm)	16.15	37.07	52.33	59.33	3.05	4.77	5.43	6.92	7.83	17.15	28.54
GA_3 (75ppm)	18.53	40.34	56.33	65.29	4.21	6.43	7.50	7.28	8.75	17.92	29.75
NAA (50ppm)	12.75	33.33	43.66	54.41	2.76	4.10	4.75	5.87	7.45	15.53	25.33
NAA (100ppm)	15.48	36.66	48.25	57.08	3.75	4.26	4.98	6.23	7.95	16.08	26.88
NAA (150ppm)	17.48	38.54	53.54	60.52	3.95	5.33	6.90	7.02	8.10	16.74	27.15
SEm±	0.44	0.74	0.49	0.37	0.19	0.11	0.16	0.20	0.08	0.38	0.27
CD at 5%	1.37	2.30	1.52	1.15	0.58	0.34	0.49	0.62	0.26	1.19	0.83

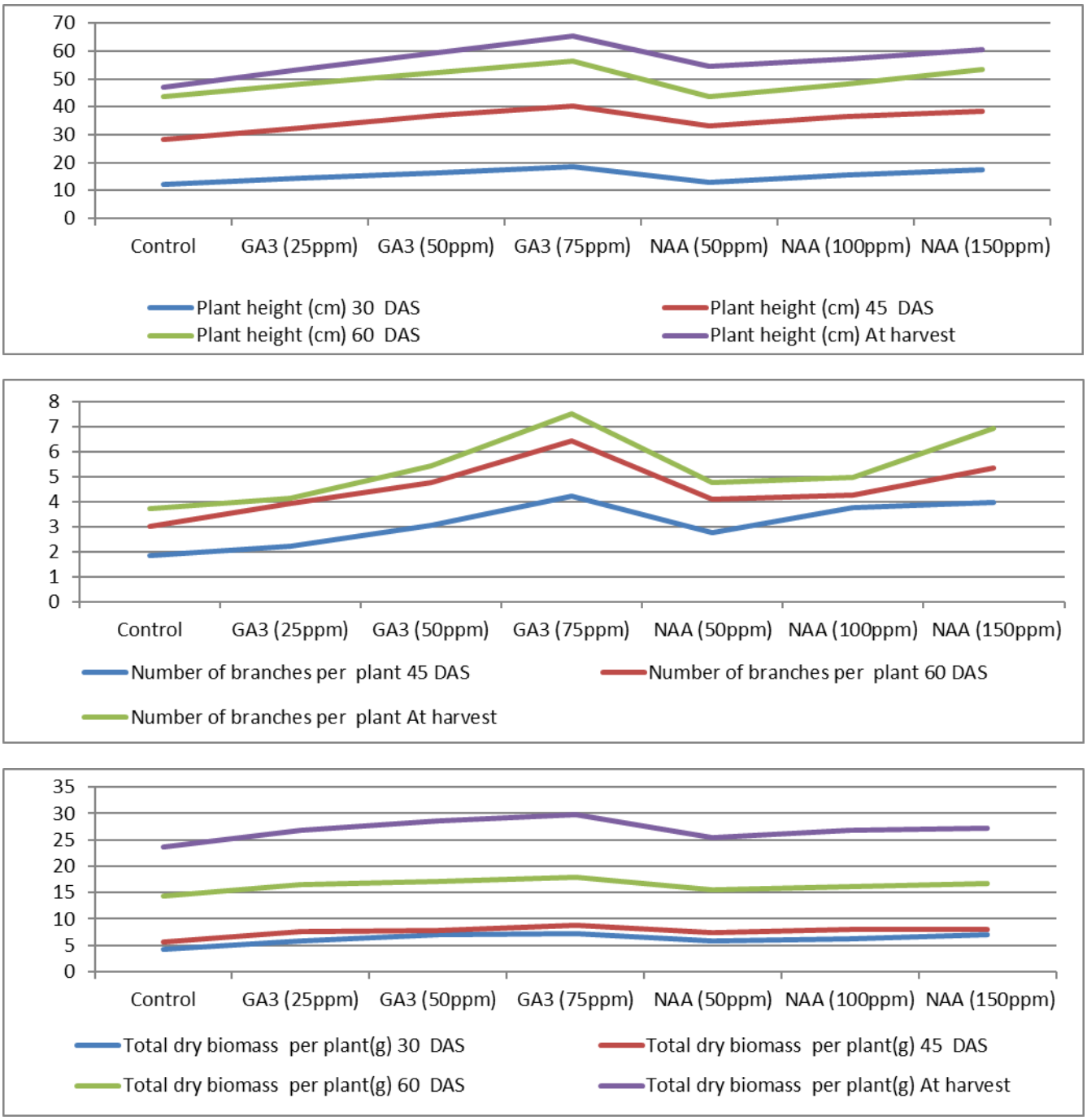

Fig 1: Effect of plant growth regulators on plant height, number of branches per plant and total dry biomass per plant of mung bean during *kharif season*

Biochemical parameters

The biochemical parameters like chlorophyll content green leaves and protein content in seeds have been significantly affected by foliar spray of plant growth regulators at various stages of the crop. The maximum chlorophyll content in leaves (9.45, 10.27, and 10.28 SPAD Value) was analyzed with foliar sprayed of GA_3-75ppm at 30, 45 and 60 DAS of the crop. The higher chlorophyll content analyzed due GA_3-75ppm which might be due to enhanced cell division and increased chloroplast development in the plant that may contribute in improving chlorophyll content in leaves. These results are supported by Shairy and Hegazi (2009) [15] conducted pot experiment to investigate the effect of $GA_3$50ppm, NAA-100ppm applied as foliar spray at different growth stages. They reported significantly increase in total chlorophyll content in leaves. Observations were also estimate for higher protein content in seeds were also estimated with foliar sprayed of GA_3-75ppm. The higher protein content in seeds estimated with $GA_3$75ppm which attributed with increased in structural component of RNA molecules of amino acids and also GA_3 cause marked increase DNA, RNA and protein synthesis in ribosome which is known as site of protein synthesis in plants. The increase in protein content was also supported by Shairy *et al*. (2009) [16] conducted pot experiment to investigate the effect of IBA (50 and 100 ppm) and GA_3 (50 and 100 ppm) on protein at different growth stages. They reported significantly increase in total soluble protein in pea, and Jain *et al*., (2008**)** [9] reported that the plants were treated with IAA, GA_3 and kinetin at stages 15 days, 30 days and 45 days after nodule initiation. It was observed that almost all growth regulators showed a general promontory effect on protein biosynthesis at lower concentrations (Bora and Sarmia, 2006) [5].

Table 2: Effect of plant growth regulators on Chlorophyll content, Nitrogen content (SPAD value) in green leaves in mature seed and protein content of mung bean during *kharif* season

Treatments	Chlorophyll content			Nitrogen content			Protein Content (%)
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	
Control	6.24	7.59	8.71	0.32	0.47	0.31	22.53
GA_3 (25ppm)	7.56	8.57	9.24	0.36	0.55	0.34	23.15
GA_3 (50ppm)	8.44	9.91	9.92	0.42	0.59	0.37	23.36
GA_3 (75ppm)	9.45	10.27	10.28	0.51	0.65	0.41	24.63
NAA (50ppm)	7.48	8.25	8.45	0.34	0.56	0.32	23.01
NAA (100ppm)	8.64	9.31	9.45	0.39	0.59	0.35	23.39
NAA (150ppm)	8.95	9.89	9.98	0.46	0.61	0.39	24.47
SEm±	0.37	0.28	0.17	0.05	0.03	0.02	0.19
CD at 5%	1.15	0.86	0.54	0.02	0.08	0.05	0.60

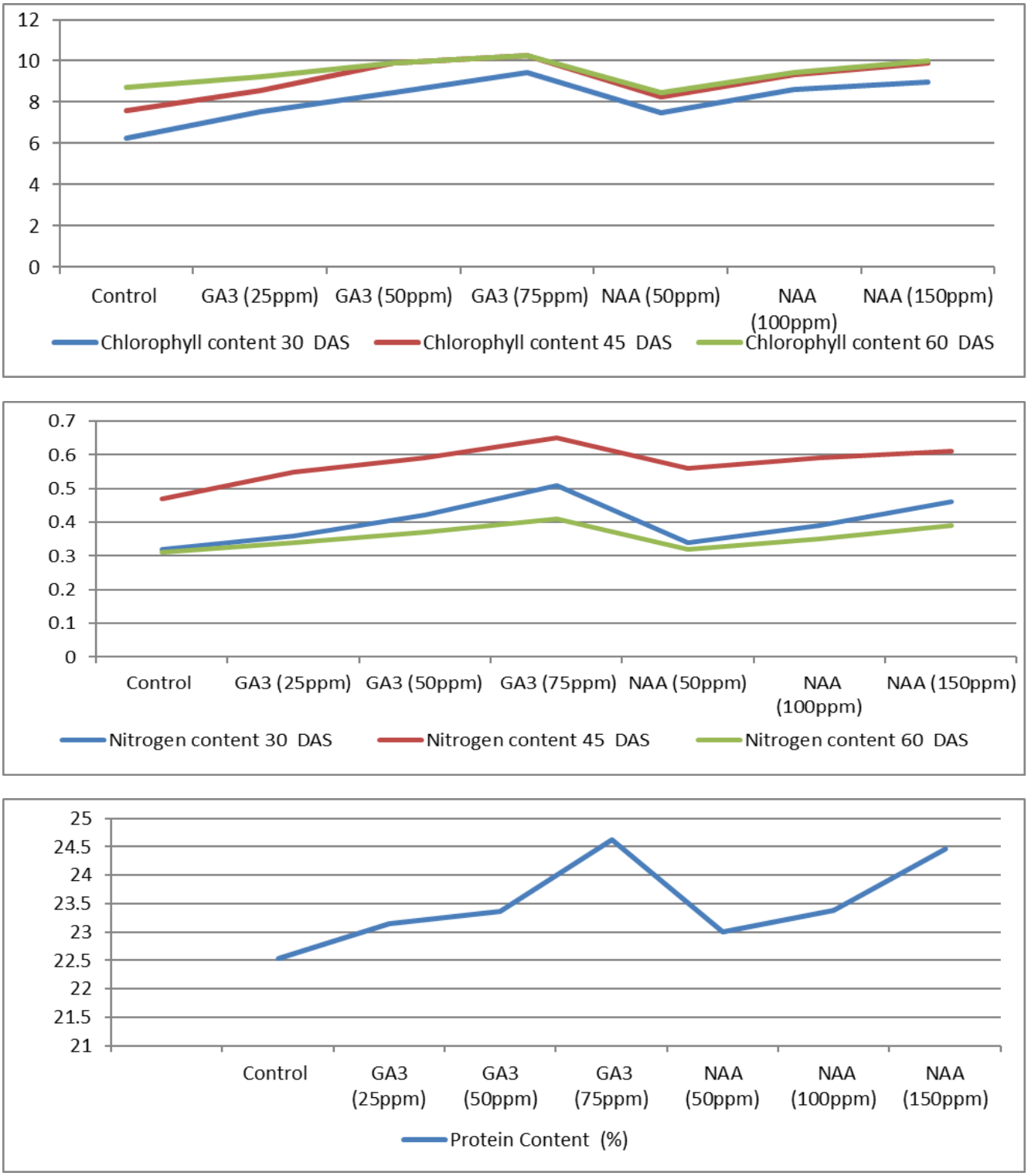

Fig 2: Effect of plant growth regulators on Chlorophyll content, Nitrogen content in green leaves in mature seed and protein content of mung bean during *kharif* season

Yield and yield attributing traits

Yield is the culmination of several comprehensive phases which starts at germination and end at harvest, encompassing through shoot growth, leaf development, photosynthesis, flowering, pollination and seed set. Yield contributing parameters as number of pod clusters per plant, number of pods per plant, pod length, number of seeds per pod, number of seeds per plant, 100 seeds weight, seed yield per plant, have been significantly increased by foliar sprayed of various plant growth regulators as compared to control. The above higher yield contributing parameters obtained with foliar sprayed of GA_3 75ppm. Followed by foliar sprayed of NAA 150ppm. Which might be due to maximum net photosynthetic rate in leaves and better translocation of photosynthetic and metabolites (nutrients etc.). Though, the way of various physiological mechanism involves in the plant with foliar sprayed of NAA-150ppm also played a significant role in enhancing above yield attributes up to some extent. The present finding is in accordance with Salman *et al*. (2015) reported that the response of foliar application of plant growth regulators (GA_3),and NAA increase number of pod cluster per plant, 100 seed weight and seed yield per plants of the mungbean. The higher number of seeds plant-^{1} obtained with foliar spray of GA_3-75 ppm may be because of increased cell division, promotion of orderly development of embryos of seeds and higher level of photosynthates that led to increase in number of seeds per plant. The similar findings also reported by Ali and Muhsen (2014) [2]. The seed yield (q ha^{-1}) was significantly affected with foliar spray of various plant growth regulators. Similar result was found by Ali and Mahmood (2013) [1]. The maximum seed yield (11.66 q ha1) was achieved with seed priming of GA_3-75 ppm closely followed by foliar spray with NAA-150 ppm (10.66 q ha^{-1}).

The higher seed yield obtained with foliar spray with GA_3 75 ppm which might be due to increased yield contributing parameters viz., number of pods clusters and pods per plant, pod length, number of seeds per pod, number of seeds per plant, 100 seed weight and seed yield per plant which in combination contributed a lot in improving seed yield (q ha-^{1}) of mung bean during present investigation. The higher harvest index (36.06%) was calculated with foliar spray of GA_3-75 ppm followed by foliar spray with NAA-150 ppm (35.55%). The present finding is conformity with Umair *et al*. (2011) [17]. These findings were accordance with Naqvi and Nooris (2014) [13] an experiment was conducted to determine the most effective PGRs for the optimum performance of chickpea cultivars.

Table 3: Effect of plant growth regulators on yield attributes of mung bean during *kharif* season

Treatments	Number of Pod Clusters Plant^{-1}	Number of Pods Plant^{-1}	Pod Length (Cm)	Number of Seed Plant^{-1}	Number of Seeds pod^{-1}	100 Seed Weight (g)	Seed yield (g) plant^{-1}
Control	3.45	35.14	4.45	307.66	5.41	2.93	10.20
GA_3 (25ppm)	4.86	40.66	5.86	348.55	7.33	3.29	12.45
GA_3 (50ppm)	6.38	45.43	7.47	386.66	8.33	3.92	13.36
GA_3 (75ppm)	7.39	48.92	8.92	445.33	9.21	3.62	15.07
NAA (50ppm)	5.63	38.74	5.19	355.07	6.97	3.30	12.26
NAA (100ppm)	6.43	41.07	6.37	401.22	7.79	3.62	12.90
NAA (150ppm)	7.15	46.51	8.17	410.38	9.12	3.74	13.37
SEm±	0.18	0.30	0.16	0.55	0.18	0.15	0.12
CD at 5%	0.57	0.94	0.49	1.71	0.56	0.46	0.39

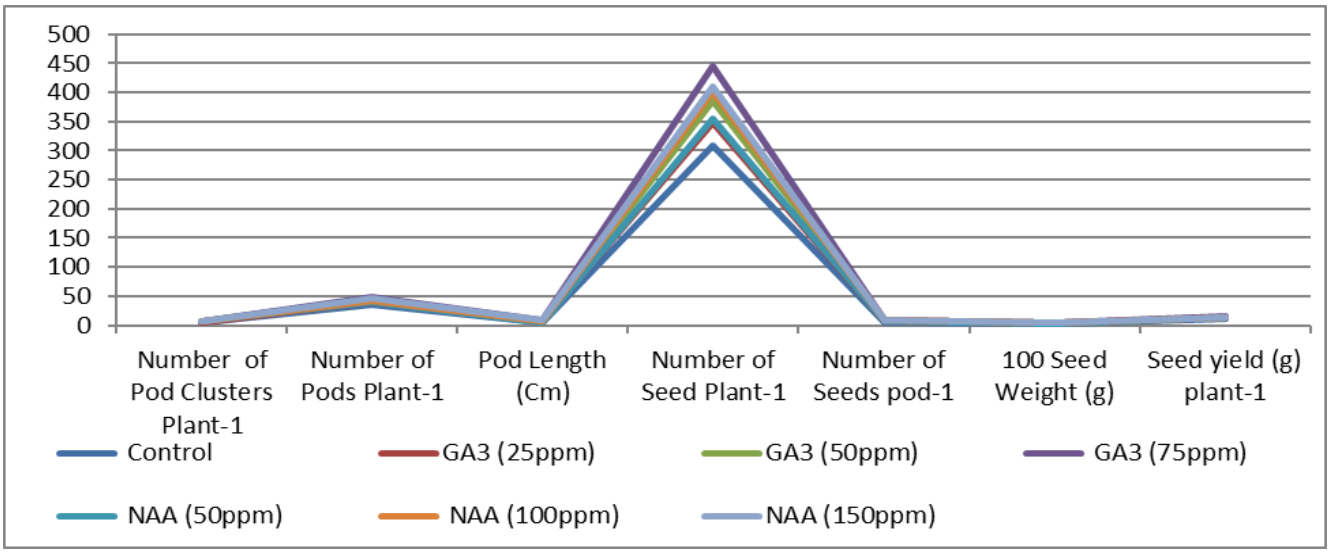

Fig 3: Effect of plant growth regulators on yield attributes of mung bean during *kharif* season

Conclusion

The present investigation concluded that foliar sprayed of GA_3 at 75ppm and NAA at 150ppm were found most effective among all treatments to increase mungbean growth, photosynthetic pigments, endogenous phytohormones, yield components, and chemical composition of the yielded seeds as low input technology for improving the yield of mungbean.

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