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Effect of irradiated chitosan on growth and yield of green gram (*Vigna radiata* L. Wilczek) in konkan region of Maharashtra

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Abstract
The current study "Effect of irradiated chitosan on growth and yield of Green gram (*Vigna radiata* L. Wilczek) in konkan region of Maharashtra". In the summer of 2022, a field experiment was carried out at the Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra. The experiment is comprised of Randomized Block Design with 6 treatments T_1: control, T_2: 30ppm, T_3:40ppm, T_4:60ppm, T_5:60 ppm, T_6:80 ppm which was replicated 4 times. 15 and 45 DAS were treated with foliar sprays of irradiation chitosan. 30x15 cm was the spacing used for sowing the green gram cultivar, TMB-37. Result found that growth parameters like plant height (cm), number of branches plant^{-1}, number of functional leaves plant^{-1}, dry matter accumulation plant^{-1} (g) and yield attributing parameters like total number of pods plant^{-1}, average weight of pod (g), pod length (cm), number of grains pod^{-1},test weight (g), grain yield (kg ha^{-1}), stover yield (kg ha^{-1}), total biomass production (kg ha^{-1}), harvest index (%) were recorded significantly maximum values in treatment T_6 (80ppm) over control.

Keywords: Irradiated, chitosan, green gram konkan, yield and yield attributing characters

1. Introduction
Green gram (*Vigna radiata* L. Wilczek) is the most economically significant legume crop. It is grown for the edible sprouts and seeds. India has been cultivating green gram since ancient times. It is a crop indigenous to Central Asia and India. The scientific name for green gram is (*Vigna radiata* L. Wilczek). The green gram has a chromosome number of (2n=22). Specifically, it belongs to the family Leguminous (fabaceae). Most warm-season green gram are grown in tropical locations that range from semi-arid to sub-humid, with 600–1000 mm of yearly 3rainfall. With a high nutritional content, green gram are an important source of protein for most vegetarians. It contain 23-24% protein, 55-65% carbohydrate, 25% albumin, 1-1.5% fat 3.5-4.5% fibre and 60% globulin, 4.5-5.5% ash on dry weight basis.

Mungbean, also referred to as moong or green gram. Among the various pulses, the green gram alone accounts for 16% of area and 10% of production. The dominant contributors to green gram cultivation in terms of area and production are Rajasthan (46% and 45% respectively), with Madhya Pradesh (9% and 14%), Maharashtra (9% and 8%), Karnataka (9% and 6%), Odisha (5% and 4%), Bihar (4% and 5%), Tamil Nadu (4% and 3%), Gujarat (3% and 4%), Andhra Pradesh (3% for both), and Telangana (2% for both) also playing significant roles, as stated in the Annual Report (2022-23) by AICRP on *Kharif* pulses.

Maharashtra is India's third largest producer of pulses. The overall area of green gram in Maharashtra was 40.38 lakh hectares, with a production area of 31.5 lakh tonnes and a total productivity of 783 kg ha^{-1}. Green gram is grown primarily in Raigad, Thane, and parts of Ratnagiri district in the Konkan region.

People began searching for ways to lessen environmental pollution by going back to nature and utilizing scientific and technological advancements to improve their quality of life. The goal of science is to produce safe, affordable, and useful products. The word "chitin" comes from the French word "chitine," which means "covering." After cellulose, chitin is the second most common naturally occurring polysaccharide in the world. Beta (1, 4)-poly-N-acetyl-D-glucosamine units repeat in a long-chain polymer to form chitin, a structural linear polysaccharide sugar.

The vital component found in the cell walls of fungus, yeast, mushrooms, and marine crustaceans-which include prawns, crabs, lobster, and shellfish-as well as other invertebrate species, insects, and green algae is chitosan. Indian commercial production of prawns and prawns from marine habitats is growing, and these seafood products are vital to the chitosan-making process.

Chitosan is derived from the natural polymer chitin. The three essential processes that could convert chitin into its most well-known derivative, chitosan, are deprotinization, demineralization, and deacetylation. The incapacity of sustainable agriculture to provide enough food for the growing global population presents numerous difficulties for the agricultural sector. The ecology and agricultural output were negatively impacted by the massive usage of chemical substances.

Chitosan plays a major role in controlling agricultural diseases and pests as well as lowering the need for fertilizer in modern farming. Given the situation, it is important to use biomaterial compounds like chitosan because it is environmental friendly. Chitosan owing to their unique properties such as they are biocompatibility, biodegradability, lack of toxicity, anti-microbial property (Badawy *et al*. 2011) [2], anti-fungal property (Abdelbasset, *et al*. 2010) [1], food preservative properties (Yu *et al*. 2012) [16]. It's called the "plant vaccine" because of its many advantages in the agricultural field.

2. Materials and Methods

The goal of the current experiment was to investigate "Effect of irradiated chitosan on growth and yield of green gram (*Vigna radiata* L. Wilczek) in konkan region of Maharashtra" during *Summer* season of 2022 on Plot No- 24, at Department of Agronomy, College of Agriculture, Dapoli, District Ratnagiri. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli which is located in the subtropical zone at 17^0 45' 43" N latitude and 73^0 10' 27" E longitude, with an elevation of roughly 178 m above mean sea level. The experiment was laid out in Randomized Block Design with four replications and six treatments. The six treatments were T_1: control (No foliar application), T_2: foliar spray of 30ppm irradiated chitosan (IC), T_3: foliar spray of 40ppm irradiated chitosan (IC), T_4: foliar spray of 50ppm irradiated chitosan (IC), T_5: foliar spray of 60ppm irradiated chitosan(IC), T_6: foliar spray of 80ppm irradiated chitosan (IC) was applied at 15 and 45 days after sowing. For this experiment, the green gram cultivar TMB-37 was used. Before sowing the green gram crop, a basal dose of 50 kg ha^{-1} of phosphorus and 25 kg ha^{-1} of nitrogen was administered. The soil of the experimental site was sandy clay loam in texture, low in available nitrogen (245 kg ha^{-1}), low in available phosphorus (11.12 kg ha^{-1}), medium in available potassium ((226.25 kg ha^{-1}), high in organic carbon (11.21 g kg^{-1}) and acidic in reaction (5.18).

3. Result and Discussion

3.1 Effect on growth parameters

Characteristics of green gram growth can be identified by recording and analyzing the data.

3.2 Plant height

Among the different treatments highest plant height was recorded (31.13 cm) was observed under treatment T_6 at harvest and which was found at par with treatment T_5 and treatment T_4. However, significantly lowest plant height (24.22 cm) was recorded in treatment T_1. The increased in plant height might be due to, chitosan is a highly promising biomolecule with molecular signals that stimulate plant growth (Gornik *et al*. 2008) [7]. According to Gornik *et al*. (2008) [7], there is a possibility that the rise in plant height is caused by an increase in the activity of important enzymes involved in nitrogen metabolism, such as glutamine synthetase, reductase, and protease, as well as increased photosynthesis. These findings concur with those of Mondal *et al*. (2012) [10] and Parvin *et al*. (2019) [12].

Table 1: Among the different treatments highest plant height was recorded

Treatments		Plant height (cm)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Control (No spray)	4.24	6.94	14.31	22.50	24.22
T_2	30ppm irradiated Chitosan	4.36	7.39	15.28	24.86	25.73
T_3	40ppm irradiated chitosan	4.52	7.40	15.40	26.10	27.57
T_4	50ppm irradiated chitosan	4.54	7.95	16.29	26.93	30.10
T_5	60ppm irradiated chitosan	4.60	8.51	16.66	26.89	30.28
T_6	80ppm irradiated chitosan	4.61	9.24	17.36	28.83	31.13
S.Em (±)		0.23	0.30	0.56	0.80	0.95
C.D. at 5%		NS	0.92	1.69	2.43	2.86

Table 2: Data on number of functional leaves plant^{-1}

Treatments		No of functional leaves plant^{-1}				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Control (No spray)	2.05	3.65	6.35	9.09	7.00
T_2	30ppm IC	2.10	3.94	7.04	9.22	7.20
T_3	40ppm IC	2.15	3.99	7.10	9.65	7.35
T_4	50ppm IC	2.30	4.40	7.41	10.50	7.79
T_5	60ppm IC	2.35	4.55	7.50	11.00	8.00
T_6	80ppm IC	2.45	4.65	8.18	11.70	8.20
S.Em (±)		0.14	0.19	0.33	0.44	0.32
C.D. at 5%		NS	0.57	0.99	1.34	NS

Number of functional leaves plant^{-1}

Data on number of functional leaves plant^{-1} was recorded at 15, 30, 45, 60 DAS and at harvest stage of crop. It was observed that at 30, 45, 60 DAS and at harvest, number of functional leaves plant^{-1} was recorded significantly maximum in treatment T_6 *i.e.*, (2.45, 4.65, 8.18, 11.70 branches plant^{-1}) which was found at par with treatment T_5 and T_4. However, treatment T_1 (Control: No foliar spray) showed the lowest number of branches plant^{-1}. The increased in number of functional leaves plant $^{-1}$ might be due to the synthesis of plant hormones like gibberellins may be induced by irradiated chitosan, leading to an increase in plant growth metrics, such as the number of functioning leaves. Moreover, it promotes growth through a tryptophan-independent mechanism that involves some signalling pathways connected to auxin production.

Number of branches plant^{-1}

Data on number of branches plant^{-1} was recorded at 30, 45, 60 DAS and at harvest stage of crop. At 45, 60 DAS and at harvest, number of branches plant^{-1} was recorded significantly maximum in treatment T_6 *i.e.*,(2.43, 3.00, 3.77 branches plant^{-1}) followed by treatment T_5 and T_4 which were at par with each other. Treatment T_1 (Control: No foliar spray) showed the lowest number of branches plant^{-1} which was (1.18, 1.40, 2.53 branches plant^{-1}). The increased in number of branches plant^{-1} might be due to, chitosan raises the growth parameter, or the number of branches, which may be the result of longer internodes due to an increase in cells or a greater number of internodes (Hong yan *et al.*, 2001) [1].

Table 3: Data on number of branches plant^{-1}

Treatments		Number of branches plant^{-1}			
		30 DAS	45 DAS	60 DAS	At harvest
T_1	Control (No foliar spray)	1.15	1.18	1.40	2.53
T_2	30ppm irradiated chitosan	1.20	1.23	1.55	2.71
T_3	40ppm irradiated chitosan	1.20	1.50	1.90	2.83
T_4	50ppm irradiated chitosan	1.25	2.10	2.65	3.45
T_5	60ppm irradiated chitosan	1.25	2.18	2.70	3.67
T_6	80ppm irradiated chitosan	1.30	2.43	3.00	3.77
S.Em (±)		0.04	0.12	0.14	0.11
C.D. at 5%		NS	0.37	0.44	0.33

Table 4: Data on dry matter accumulation

Treatments		Dry matter accumulation plant^{-1} (g)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Control(No spray)	0.10	0.82	1.17	8.32	9.13
T_2	30ppm irradiated chitosan	0.11	0.88	1.74	8.23	9.58
T_3	40ppm irradiated chitosan	0.11	0.88	1.77	8.52	9.88
T_4	50ppm irradiated chitosan	0.12	0.99	1.95	9.21	10.07
T_5	60ppm irradiated chitosan	0.12	1.00	1.99	9.49	10.60
T_6	80ppm irradiated chitosan	0.13	1.07	2.14	10.07	10.95
S.Em (±)		0.007	0.03	0.11	0.33	0.30
C.D. at 5%		NS	0.10	0.33	1.00	0.92

Dry matter accumulation plant^{-1} (g)

Data on dry matter accumulation plant^{-1} (g) was recorded at 15 DAS upto harvest. Dry matter accumulation plant^{-1} did not differ significantly due to different treatments at 15 DAS. Significantly maximum dry matter accumulation plant^{-1} (g) was recorded with foliar application of 80ppm irradiated chitosan which was 1.07, 2.14, 10.07 10.95. However, treatments T_5 (60ppm irradiated chitosan foliar spray) and T_4 (50ppm irradiated chitosan via foliar spray) were statistically at par with the treatment T_6. Treatment T_1 *i.e.,* control (No foliar spray) which recorded lowest values of dry matter accumulation plant^{-1} during periodical observation. According to the results of the current study, chitosan may have a good influence on plant growth by enhancing nutrient intake of components like potassium, phosphorus, and nitrogen. This could explain the increase in plant growth indices. Potassium and phosphorus are vital nutrients that are required for cell division, cell turger, DNA and RNA formation, and the production and translocation of carbohydrates these findings also supported.

3.2 Effect on yield and yield attributes

Total number of pods^{-1} (16.91), weight of pods (12.85 g), pod length (7.84 cm), number of grains pods^{-1} (8.97), grain yield plant^{-1} (6.79 g), stover yield plant^{-1} (8.23 g) was recorded higher in treatment T_6 (80ppm irradiated chitosan via foliar spray). However, treatment T_5 (60ppm irradiated chitosan via foliar spray) and treatment T_4 (50ppm irradiated chitosan via foliar spray) were statistically at par to the treatment T_6. This might be due to chitosan application may have increased yield because it stimulates physiological processes, improves vegetative growth, and then actively transfers photo-assimilates from source to sink tissues. It may also have increased leaf blade thickness and vascular bundle dimensions. Improved photosynthetic equipment could be the cause of the increases in plant biomass Khan *et al.* (2002) [9]. Our findings concur with those of Parvin *et al.* (2019) [12], Mondal *et al.* (2013) [11].

Yield is a result of yield-attributing characteristics. The yield attributing components, such as total number of pods^{-1}, average weight of pod (g), pod length (cm), and number of grains pod^{-1}, primarily influenced the higher levels of grain, straw, biological yield, and harvest index in the current experiment. Thus, significantly higher grain yield (1100 kg ha^{-1}), stover yield (1597 kg ha^{-1}), biological yield (2697 kg ha^{-1}), harvest index (40.97%) was recorded with treatment T_6 (80ppm irradiated chitosan via foliar spray). However, treatment T_5 (60ppm irradiated chitosan via foliar spray) and treatment T_4 (50ppm irradiated chitosan via foliar spray) were statistically at par to the treatment T_6.

The increasing in yield might be directly associated with concomitant increase in growth and yield attributes of green gram plant because of improved nutritional environment in the plant metabolic system leading to higher plant metabolism and photosynthetic activity due to Chitosan. This excess assimilates stored in the leaves and later translocated into seeds at the time of senescence, ultimately resulted in to higher yield. Among various Chitosan levels treatments foliar spray of 80 ppm concentration sprays produced more number of branches, number of pods than the remaining sprays. It might be due to the reason that 80 ppm concentration helped to enhanced more enzymatic activities constantly with greater nutrient availability hasten the photosynthetic activities in the plant resulting in creation of more dry matter which lead to more number of branches, pods per plant.

The potential cause of the yield increase could be attributed to the stimulatory action of chitosan on physiological processes, as well as better nitrogen transfer in functioning leaves, leading to improved vegetative growth and development. Given that chitosan is a novel plant growth promoter that may have an impact on plant growth and yield, its strong effects on foliar spraying may be explained EI-Bassiony *et al*. (2014) [5]. In order to effectively aid in flower formation, fruit and seed development, and eventually increase agricultural yield, plant growth regulators are known to improve the source-sink connection and stimulate the translocation of photo-assimilates. Growth regulators can increase photosynthetic capacity and improve how well aggregates are partitioned between sources and sinks in field crops. These findings correlate with those of Parvin *et al*. (2019) [12], Mondal *et al*. (2013) [11], Mondal *et al*. (2012) [10], Gawande *et al*. (2021) [6], Wan *et al*. (2021) [15].

Table 5: Total number of pods weight length grains

Treatments		Total number of pods plant^{-1}	Weight of pods (g)	Pod length (cm)	Number of grains pod^{-1}	1000 grain weight (g)	Grain yield plant^{-1} (g)	Stover yield plant^{-1} (g)
T_1	Control: No foliar spray	13.83	10.60	6.39	7.20	34.24	4.60	6.45
T_2	30 ppm irradiated chitosan foliar spray at 15 and 45 DAS	14.20	11.15	6.84	7.91	34.36	4.70	6.72
T_3	40 ppm irradiated chitosan foliar spray at 15 and 45 DAS	14.44	11.28	7.06	7.95	34.52	4.72	6.34
T_4	50 ppm irradiated chitosan foliar spray at 15 and 45 DAS	15.60	11.85	7.19	8.38	34.54	6.06	7.89
T_5	60 ppm irradiated chitosan foliar spray at 15 and 45 DAS	15.95	12.55	7.65	8.52	34.60	6.46	7.97
T_6	80 ppm irradiated chitosan foliar spray at 15 and 45 DAS	16.91	12.85	7.84	8.97	34.61	6.79	8.23
S.Em. **(±)**		0.55	0.44	0.23	0.29	0.23	0.25	0.25
C.D. at 5%		1.67	1.33	0.69	0.90	NS	0.75	0.77
General Mean		15.15	11.71	7.16	8.15	34.48	5.55	7.37

Conclusion

This experiment shows that, treatment T_6 (80 ppm irradiated chitosan via foliar spray) with 2 sprays at 15 and 45 days after sowing along with recommended dose of fertilizer recorded maximum growth parameters and yield attributes and recorded highest grain yield in green gram.

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