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Effect of Seed Priming and Foliar Spraying of PGRs on Morpho-Physiology, Growth and Yield in Green gram (*Vigna radiata* L.)

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ABSTRACT

Background: Pre-sowing seed priming and foliar spraying with Plant Growth Regulators is an easy, low cost and low risk technique and also an alternative approach recently used to mitigate the effect of abiotic stresses in agricultural production.

Methods: Seeds of Mung bean *var*. GAM-5 were primed and also foliar spraying at 30 DAS with $CaCl_2$ 2% and 1%, Cycocel 500, 1000 ppm, NAA 25, 50 ppm during *summer* season of 2015-16 and 2016-17.

Result: The results indicated a significant improvement in morpho-physiological traits, growth parameters, biochemical constituents and thereby yield due to the application of PGRs. Seed priming with 2% $CaCl_2$ followed by 1% foliar spraying at 30 DAS (T_{11}) significantly improved most of morpho-physiological parameters *viz*., plant height, number of branches per plant, days to 50% flowering, maturity, leaf area, chlorophyll content, seed protein content, number of pods per plant, number of seeds per pod, test weight, pod length, yield per plant, yield per hectare, harvest index in green gram followed by the seed priming with Cycocel 1000 ppm followed by foliar spraying at 30 DAS (T_{13}) and seed priming with NAA 50 ppm followed by foliar spraying at 30 DAS (T_{15}). The treatment T_{11} was more efficient.

Key words: $CaCl_2$, Cycocel, Chlorophyll, Foliar spray, Mung bean, NAA, Seed priming, SPAD.

INTRODUCTION

Mung bean (*Vigna radiata* L.) is an important pulse crop having high nutritive value, suitable for dry land farming and predominantly used as an intercrop with other crops. It contains about 25 per cent protein along with amino acids such as arginine, histidine, lysine and tryptophane *etc*. It is also considered as a cheap source of protein and other minerals. It has high digestibility and palatability (Vikram *et al*., 2019). It is a very good catch crop in summer and can be grown very well in this season. Mung bean is a short duration, low input requiring crop that matures in 65 to 80 days, photo and thermo-insensitive in nature. However, the productivity of mung bean is low.

Efforts made to maximize yield, is largely hampered by adverse effect of abiotic stress such as salinity and drought. These effects cause a huge loss due to low yield and failure of the crop to establish in some cases. Pre-sowing seed priming treatment is simple technique and an alternative approach recently used to overcome the effect of abiotic stresses in agricultural production. It is found to be efficient in improving seed emergence and growth of crops (Sankar Ganesh *et al*., 2013). It was reported clearly that the hardening treatment enhance seeds vigour by protecting structure of the plasma membrane against injury during stress (Bewley and Black, 1982; JunMin *et al*., 2000). It is a well established fact that, pre-soaking seeds with optimal concentration of phytohormones enhance their germination, dry matter accumulation, partitioning and yield of some crop species under condition of environmental stress by increasing nutrient reserves through increased physiological activities and root proliferation (Bozeuk, 1981).

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Considering the constraints in the production potential of mung bean it is worthwhile to study the influence of different seed hardening and foliar spraying treatments on the production potential of mung bean. It is also of utmost importance to understand the physiological basis of yield attributing characters, partitioning in various plant parts and thereby yield variation due to seed hardening and foliar spraying of various growth regulators and chemicals. The pre-requisite for higher yield is related with the ability of genotype to produce high amount of total dry matter. Patil *et al*., (2007) reported that the manner in which the net dry matter is produced and distributed among the different parts of plant will determine the economic yield. The present study was therefore, undertaken to assess the morpho-physiological, growth and yield attributing characters in relation to yield in green gram.

MATERIALS AND METHODS

The present work was carried out at Agronomy farm, Anand Agricultural University, Anand to study the effect of seed hardening, foliar spraying and their combined effect on morpho-physiology, growth and yield in green gram (*Vigna radiata* L.) during *summer* season of 2015-16 and 2016-17. The trial was laid out in a randomized block design with three replications and sixteen treatment combinations including five seed hardening treatments, five foliar spraying treatments, five seed hardening treatments with foliar spraying and one absolute control treatment. Seeds of mung bean *var.* GAM-5 were imposed with the following seed treatments.

The different solutions of plant growth regulators (PGRs) *viz.*, $CaCl_2$ 2%, Cycocel 500, 1000 ppm and NAA 25, 50 ppm were prepared for seed hardening. PGRs treatments were given to sufficient quantity of seeds of Mung bean cv. GAM-5 for hardening, seeds were soaked in above prepared various solutions of double the volume of seed for three hours. This will ensure that seeds remained immersed in the solution, so as to avoid precocious germination during the treatment period. Hardening was given in flasks under room temperature. The seeds were then removed from respective solutions and kept overnight in shade for drying to attain the seeds to its original moisture level. The seeds were ready for sowing in field on next day.

The different solutions with their different concentrations were used in this experiment for foliar spraying at field level. The spraying solutions of $CaCl_2$ 1%, Cycocel 500, 1000 ppm and NAA 25, 50 ppm were prepared. The spraying was carried out as per treatments during the morning time or before noon at 30 days after sowing (DAS) in respective gross plot of each replication using knapsack sprayer.

Morpho-physiological and growth parameters

Plant height, number of branches per plant, number of nodes per plant, days to 50% flowering, days to maturity were recorded by non destructive method from each replication and treatment and the average values were calculated.

Leaf Area (cm^2 $plant^{-1}$)

Leaf area per plant was taken at harvest with the help of Leaf area meter (BIOVIS Company Model- 3100) at Regional Research Station, AAU, Anand. Five plants were randomly selected from all replications and clipped and recorded.

Estimation of Total Leaf Chlorophyll Content

Total chlorophyll content was estimated by the SPAD (soil plant analytical development) meter in which randomly three leaves were selected from lower, middle and upper portion at harvest. Before the measurement, instrument is calibrated - transmission is measured with no leaf inside. Thus, when a leaf is clamped by the meter, a certain portion of red light is absorbed and the meter can calculate a relative value (in SPAD), showing how green the leaf is. Basically, SPAD value correlates with actual chlorophyll content in the leaf, but measurements have to be taken at many points of the same leaf to be representative and calibration is to be performed for every plant species or cultivar to know the exact relationship between SPAD values and chlorophyll contents per unit area.

Measurement of Seed Protein Content (%)

The protein content was determined by Micro-Kjeldhal method (AOAC, 1990). The method consists of heating a substance with sulphuric acid, which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate. In this step potassium sulphate was added to increase the boiling point of the medium (from 337°C to 373°C). Chemical decomposition of the sample was completed when the initially very dark-coloured medium has become clear and colourless. The solution was then distilled with a small quantity of sodium hydroxide, which converts the ammonium salt to ammonia. The amount of ammonia present and thus the amount of nitrogen present in the sample, was determined by back titration. The end of the condenser was dipped into a solution of boric acid. The ammonia reacts with the acid and the remainder of the acid was then titrated with a sodium carbonate solution by way of a methyl orange pH indicator.

Protein (%) = N (%) X 6.25

Yield and yield components

Tagged plants used for recording morphological observations were harvested at physiological maturity and were used for recording the yield and yield components *viz.*, number of pods per plant, length of pod (cm), number of seeds per pod, 1000 seed weight (Test weight) (g), seed yield per plant (g $plant^{-1}$), seed yield per hectare (Kg ha^{-1}) and harvest index (%).

RESULTS AND DISCUSSION

Plant height

Table 1 represents that at harvest, plant height was maximum in the treatment of $CaCl_2$ 2% seed hardening + 1% foliar spraying at 30 DAS (T_{11}) (37.00, 40.67 and 38.83 cm) and remained at par with NAA 50 mg/L seed hardening + spraying at 30 DAS (T_{15}) (35.67, 39.33 and 37.50 cm), NAA 25 mg/L seed hardening + spraying at 30 DAS (T_{14}) (34.67, 37.50 and 36.08 cm) and $CaCl_2$ 1% spraying at 30 DAS (T_6) (33.67, 37.00 and 35.33 cm). While Cycocel 1000 mg/L spraying at 30 DAS (T_8) recorded significantly less plant height (23.67, 26.00 and 24.83 cm) during the year 2016, 2017 and pooled basis, respectively.

Plant height was increased due to treatments of $CaCl_2$ and NAA, while decreased due to Cycocel at harvest in green gram. The decrease in plant height with cycocel may be attributed to anti-gibberellic activity of Cycocel mainly by blocking certain steps of gibberellin biosynthesis so that gibberellin is not made available for participation in plant growth (Jain, 2013). The mechanism of reduction of plant

Table 1: Effect of seed hardening, foliar spraying and their combined effect on Plant height, No. of branches, Leaf area at harvest.

Treat. No.	Treatment Details	Plant height (cm)			Number of Branches per plant			Leaf Area (cm^2 plant^{-1})		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	$CaCl_2$ 2% SH	31.00	34.83	32.92	7.07	7.27	7.17	262	310	286
T_2	CCC 500 mg/L SH	28.67	31.33	30.00	6.93	7.13	7.03	255	300	278
T_3	CCC 1000 mg/L SH	30.33	33.33	31.83	7.13	7.33	7.23	260	308	284
T_4	NAA 25 mg/L SH	28.33	31.00	29.67	6.73	6.87	6.80	240	286	263
T_5	NAA 50 mg/L SH	29.33	32.00	30.67	6.87	7.00	6.93	258	303	281
T_6	$CaCl_2$ 1% spraying at 30 DAS	33.67	37.00	35.33	7.67	7.87	7.77	304	353	329
T_7	CCC 500 mg/L spraying at 30 DAS	24.67	27.00	25.83	7.47	7.73	7.60	278	326	302
T_8	CCC 1000 mg/L spraying at 30 DAS	23.67	26.00	24.83	7.80	7.93	7.87	297	345	321
T_9	NAA 25 mg/L spraying at 30 DAS	32.00	35.00	33.50	7.27	7.40	7.33	270	321	296
T_{10}	NAA 50 mg/L spraying at 30 DAS	32.67	35.50	34.08	7.40	7.60	7.50	285	332	309
T_{11}	$CaCl_2$ 2% SH + 1% spraying at 30 DAS	37.00	40.67	38.83	8.33	8.87	8.60	362	428	395
T_{12}	CCC 500 mg/L SH + spraying at 30 DAS	27.00	29.33	28.17	8.20	8.47	8.33	341	395	368
T_{13}	CCC 1000 mg/L SH + spraying at 30 DAS	26.00	27.67	26.83	8.40	8.93	8.67	355	418	387
T_{14}	NAA 25 mg/L SH + spraying at 30 DAS	34.67	37.50	36.08	8.00	8.27	8.13	325	376	351
T_{15}	NAA 50 mg/L SH + spraying at 30 DAS	35.67	39.33	37.50	8.13	8.40	8.27	344	404	374
T_{16}	Absolute Control	27.67	30.33	29.00	6.53	6.80	6.67	223	264	244
	S.Em. ±	2.28	2.47	1.51	0.44	0.51	0.30	15.16	16.81	10.24
	C.D. @ 5%	6.58	7.13	4.26	NS	NS	0.85	44	49	29
	C.V. %	13.09	12.97	13.04	10.13	11.41	10.81	9.02	8.52	8.76

height by spraying with Cycocel also appears due to reduced cell size and cell wall thickening (Ginzo *et al*., 1977). Similarly, Dighe *et al*. (1983) also observed that 500 ppm cycocel significantly reduced the plant height in wheat.

It was observed that NAA showed a positive effect on plant height. The application of auxin in plant has a role in the stimulation of RNA and protein synthesis and greater enhancement in photosynthesis rate, increased in cell elongation as well as cell division and cell wall plasticity, which ultimately showed the enhancement in various growth parameters. The above finding were in agreement with the results reported by Ananthi and Mallika (2014) in green gram, Sunil Jadhav (2016) and Kinjal (2017) in black gram, Upadhyay *et al*. (2016) in soybean, Pothalkar (2007) in pigeon pea, Amarjeet Singh (2014) in turmeric, Sujatha *et al.* (2017) in chickpea.

Number of branches

At harvest, the number of branches per plant found statistically non significant during both the years. However, in pooled mean basis the treatment Cycocel 1000 mg/L seed hardening + spraying at 30 DAS (T_{13}) recorded significantly higher (8.67) than untreated absolute control with minimum number of branches per plant (6.67).

The reduction in plant height due to growth retardants is mainly seems to have released the apical dominance and diversion of the plant metabolites from vertical growth to horizontal growth and thereby more number of branches per plant. These results are in conformity with the findings of Avijit Sen (1983) in wheat, Arjun Sharma *et al*. (2003) in pigeon pea, Manjunath and Dhanoji (2011) and Sujatha (2014) in chickpea.

Leaf area

Leaf area per plant gradually decreased towards harvesting stage in green gram. The data reported in Table 1 indicated that the treatment $CaCl_2$ 2% seed hardening + 1% spraying at 30 DAS (T_{11}) registered higher values of leaf area (362, 428 and 395 cm^2) over all other treatments. It was followed by T_{13} (355, 418 and 387 cm^2), T_{15} (344, 404 and 374 cm^2) and T_{12} (341, 395 and 368 cm^2) during 2016, 2017 and in pooled analysis, respectively. Whereas, the treatment absolute control (T_{16}) recorded significantly lower value of leaf area per plant (223, 264 and 244 cm^2, respectively).

The increased in leaf area by seed hardening and foliar spraying with $CaCl_2$ and NAA might be due to increase in cell division, cell enlargement as well as induce more extensive and denser network of veins and ribs and there by increased foliar leaf area. These results are conformity with the finding of Thirumalaiswamy and Rao (1977) in pearl millet, Ginzo *et al.* (1977) and Josana (2015) in chick pea, Shinde and Jadhav (1995) in cowpea, Pothalkar (2007) in pigeon pea, Prakash *et al.* (2013) in rice and Kinjal (2017) in black gram.

Days to 50% flowering

The data indicated in Table 2 showed non significant differences due to various treatments in both the years but in pooled basis differences were significant. In pooled analysis, the treatment T_{11} (36.67) significantly taken minimum days to 50 per cent flowering followed by the treatments T_{13} (37.00), T_{15} (37.17), T_{12} (37.50) and T_{14} (37.83). While untreated absolute control (T_{16}) recorded significantly maximum number of days (42.00) to 50 per cent flowering. This might be due to early and faster emergence. Flower initiation is an important phonological development stage which determines the plant productivity.

It is inferred that, both the phenological stages *viz.,* flower initiation and pod initiation were early due to seed hardening followed by the use of plant growth regulator's spray. Similar reports have been also made by Garai and Datta (2003) in green gram and Varma *et al.,* (2004) in pigeon pea. The results in present investigation showed that minimum days taken for 50 per cent flowering in combined effect of seed hardening + foliar spraying followed by only foliar spraying and then only seed hardening treatments. In general, combined effect of seed hardening and foliar spraying was more effective in early flowering as compared to their individual effect.

Days to maturity

The data indicated non significant differences due to various treatments during both the years but in pooled analysis differences were significant. The treatment T_{11} (73.17) taken minimum days to maturity followed by the treatments T_{13} (73.50), T_{15} (73.83), T_{12} (74.33) and T_{14} (74.67). The untreated absolute control (T_{16}) (79.00) taken significantly maximum number of days to maturity.

Similar observations on advancement of flowering and harvest times were also reported by Pawar *et al.* (2003) and Narayanareddy and Biradarpatil (2012) in sunflower, Pothalkar (2007) in pigeonpea, Manjunatha (2007) and Sujatha (2014) in chickpea.

Chlorophyll content of leaves

The chlorophyll content of leaves gradually decreased towards harvesting stage in green gram. The treatment T_{11} registered significantly highest values of chlorophyll content of leaves-SPAD values (13.32, 14.80 and 14.06) over absolute control (T_{16}) (9.30, 10.47 and 9.88) and remained at par with T_{13} (13.22, 14.68 and 13.95), T_{15} (12.85, 14.43 and 13.64), T_{12} (12.68, 14.32 and 13.50) and T_{14} (12.20, 14.00 and 13.10) during 2016, 2017 and on pooled basis respectively.

From the data it is clear that continuous increase in chlorophyll content was noted up to 60 DAS, thereafter it decreased during both the seasons at senescence stage. The agrochemicals and growth substances such as $CaCl_2$, Cycocel and NAA had a positive effect on cell division and cell elongation leading to enhanced leaf expansion, leaf area and thereby chlorophyll content also. The increase in chlorophyll content due to growth regulators and agrochemical may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. These results are in accordance with Jayakumar and Thangaraj (1998), Shinde and Jadhav (1995), Dashora and Jain (1994),

Table 2: Effect of seed hardening, foliar spraying and their combined effect on Flowering, Maturity, Biochemical parameters at harvest.

Treat. No.	Treatment Details	50% Flowering (Days)			Maturity (Days)			Chlorophyll Content of Leaves (SPAD values)			Seed Protein Content (%)		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	$CaCl_2$ 2% SH	40.33	39.33	39.83	77.33	75.33	76.33	10.35	11.87	11.11	23.87	23.67	23.77
T_2	CCC 500 mg/L SH	40.67	39.67	40.17	78.00	76.00	77.00	9.80	10.93	10.37	23.53	23.37	23.45
T_3	CCC 1000 mg/L SH	40.33	39.33	39.83	77.33	75.33	76.33	10.13	11.47	10.80	23.72	23.57	23.64
T_4	NAA 25 mg/L SH	41.00	40.33	40.67	78.33	76.33	77.33	9.63	10.73	10.18	23.47	23.23	23.35
T_5	NAA 50 mg/L SH	40.67	39.33	40.00	77.67	75.67	76.67	10.00	11.30	10.65	23.63	23.42	23.53
T_6	$CaCl_2$ 1% spraying at 30 DAS	38.67	38.00	38.33	76.33	74.00	75.17	11.30	13.12	12.21	24.77	24.35	24.56
T_7	CCC 500 mg/L spraying at 30 DAS	39.33	38.67	39.00	77.00	74.67	75.83	10.78	12.45	11.62	24.28	24.02	24.15
T_8	CCC 1000 mg/L spraying at 30 DAS	39.00	38.00	38.50	76.33	74.00	75.17	11.17	12.93	12.05	24.58	24.23	24.41
T_9	NAA 25 mg/L spraying at 30 DAS	40.00	39.00	39.50	77.00	75.00	76.00	10.42	12.13	11.28	24.08	23.82	23.95
T_{10}	NAA 50 mg/L spraying at 30 DAS	39.00	38.33	38.67	76.67	74.33	75.50	11.00	12.62	11.81	24.42	24.12	24.27
T_{11}	$CaCl_2$ 2% SH + 1% spraying at 30 DAS	37.00	36.33	36.67	74.00	72.33	73.17	13.32	14.80	14.06	25.80	25.72	25.76
T_{12}	CCC 500 mg/L SH + spraying at 30 DAS	37.67	37.33	37.50	75.33	73.33	74.33	12.68	14.32	13.50	25.15	24.95	25.05
T_{13}	CCC 1000 mg/L SH + spraying at 30 DAS	37.33	36.67	37.00	74.33	72.67	73.50	13.22	14.68	13.95	25.48	25.20	25.34
T_{14}	NAA 25 mg/L SH + spraying at 30 DAS	38.00	37.67	37.83	75.67	73.67	74.67	12.20	14.00	13.10	25.03	24.72	24.88
T_{15}	NAA 50 mg/L SH + spraying at 30 DAS	37.33	37.00	37.17	74.67	73.00	73.83	12.85	14.43	13.64	25.27	25.00	25.13
T_{16}	Absolute Control	42.33	41.67	42.00	79.67	78.33	79.00	9.30	10.47	9.88	23.08	22.55	22.82
	S.Em. ±	1.11	1.17	0.69	1.66	1.88	1.13	0.92	0.99	0.61	0.66	0.77	0.46
	C.D. @ 5%	NS	NS	1.93	NS	NS	3.18	2.65	2.86	1.71	NS	NS	1.28
	C.V. %	4.88	5.26	5.07	3.76	4.37	4.07	14.27	13.55	13.90	4.69	5.55	5.13

Pothalkar (2007) and Kinjal (2017) in groundnut, cowpea, soybean, pigeon pea and blackgram respectively. In the present investigation, the chlorophyll content showed a positive correlation with grain yield indicating its importance in yield determination.

Seed Protein content (%)

The data presented in Table 2 indicated that even though, the statistically non significant differences observed for the seed protein content during both the years but protein content was improved due to the different treatments. The two years pooled data revealed that the seed protein content recorded maximum (25.76%) in the treatment T_{11} and it remained at par with the treatments T_{13} (25.34%), T_{15} (25.13%), T_{12} (25.05%), T_{14} (24.88%) and T_6 (24.56%) in pooled. While, the untreated absolute control treatment (T_{16}) recorded significantly lowest (22.82%) seed protein content.

From the above results, it is clear that there was increase in seed protein content in all the treatments like seed hardening, foliar spraying singly or their combined effect as compared to control. Similarly, the higher seed protein content was reported by Sujatha (2014) in chickpea. Avijit and Misra, (1987) in wheat, Doijode (1975) in garden peas, Bora and Sarma (2005) in pea. Shukla *et al.* (2018) in chickpea and Kumar *et al.* (2015) in field bean and Damor and Patel (2018) in mung bean.

Total Number of pods per plant

The data regarding total number of pods per plant influenced due to different treatments during both the years and on pooled basis were recorded and analyzed are recorded in Table 3. The significantly highest total number of pods per plant (33.73, 35.67 and 34.70) were recorded by the treatment T_{11}, while lowest observed in absolute control (22.00, 23.33 and 22.67) and remained at par with the treatments T_{13} (32.80, 34.93 and 33.87), T_{15} (32.13, 34.47 and 33.30), T_{12} (31.60, 33.67 and 32.63) and T_{14} (31.00, 33.07 and 32.03) during 2016, 2017 and in pooled, respectively.

Pod Length

The significantly highest pod length (8.45) was recorded in the treatment $CaCl_2$ 2% seed hardening + 1% spraying at 30 DAS (T_{11}) in pooled analysis. The treatment T_{11} was also remained at par with the treatments T_{13} (8.40), T_{15} (8.33), T_{12} (8.03) and T_{14} (7.98). The treatment untreated absolute control (T_{16}) recorded significantly the lowest pod length (7.10).

Number of seeds per pod

The treatment T_{11} recorded significantly higher number of seeds per pod (11.93) on pooled basis and remained at par with the treatments T_{13} (11.83), T_{15} (11.57), T_{12} (11.43), T_{14} (11.33), T_6 (11.08) and T_8 (11.00). While, the treatment absolute control (T_{16}) recorded significantly lowest (9.73) number of seeds per pod.

Test weight (g)

The treatment $CaCl_2$ 2% seed hardening + 1% spraying at 30 DAS (T_{11}) recorded significantly maximum (53.80 g) thousand seeds weight in pooled analysis and remained at par with the treatments *viz.*, T_{13}, T_{15}, T_{12}, T_{14}, T_6, T_8, T_{10}, T_7 and T_9. Whereas, the treatment of absolute control (T_{16}) recorded significantly the minimum (49.27 g) thousand seed weight.

Seed yield per plant (g plant^{-1})

The treatment $CaCl_2$ 2% seed hardening + 1% spraying at 30 DAS (T_{11}) recorded significantly higher values of seed yield per plant (13.07, 14.20 and 13.63 g) and remained at par with T_{13} (12.60, 13.93 and 13.27 g), T_{15} (12.47, 13.60 and 13.03 g) and T_{12} (12.13, 13.27 and 12.70 g) during 2016, 2017 and on pooled basis, respectively. Whereas, the treatment of absolute control (T_{16}) recorded significantly the lowest seed yield per plant (8.07, 9.40 and 8.73 g, respectively).

Seed yield (kg ha^{-1})

The significantly highest seed yield per hectare (949, 1006 and 978 kg ha^{-1}) was recorded by the treatment T_{11} while significantly the lowest was observed in the absolute control (639, 679 and 659 kg ha^{-1}) during 2016, 2017 and in pooled analysis, respectively and remained at par with the treatments T_{13} (922, 964 and 943 kg ha^{-1}) and T_{15} (893, 917 and 905 kg ha^{-1}).

Harvest Index (%)

The treatment $CaCl_2$ 2% seed hardening + 1% spraying at 30 DAS (T_{11}) recorded significantly highest harvest index (30.15%) in pooled analysis and remained at par with the treatments T_{13} (30.01%), T_{15} (29.84%), T_{12} (29.49%), T_{14} (29.27%), T_6 (28.80%), T_8 (28.66), T_{10} (28.35%) and T_7 (28.34%). While, the treatment of absolute control (T_{16}) recorded significantly the lowest (26.84%) harvest index.

Grain yield is the manifestation of morphological, physiological, biochemical, biophysical and growth parameters. Improvement in yield according to Humphries (1979) could happen in two ways i.e., by adopting the existing varieties to grow better in their environment or by altering the relative proportion of different plant parts so as to increase the yield of economically important parts. The influence of plant growth regulators and seed hardening chemicals significantly increased the seed yield.

In the present investigation, it is observed that the number of pods per plant, pod length, seed yield, number of seeds per pod, 1000 - seed weight increased due to seed hardening or foliar spraying alone and/or in combination of both by agrochemical $CaCl_2$ and growth regulators NAA and Cycocel.

The present study also revealed that increase in seed yield was significantly higher in seed hardening + spraying with $CaCl_2$ (2% seed hardening and 1% spraying) followed by Cycocel 1000 mg/L and NAA 50 mg/L. This could probably be due to beneficial effects of agrochemical and plant growth regulator treatments which help in enhancement of photosynthesis and nitrogen metabolism which are the major physiological process influencing plant growth and development. The treatments of $CaCl_2$ was significantly superior as compared to other treatments in enhancing the plant height, days to flowering, chlorophyll content, number

Table 3: Effect of seed hardening, foliar spraying and their combined effect on Pod characters at harvest.

Treat. No.	Treatment Details	Total No. of Pods/plant			Pod Length (cm)			Total No. of Seeds/pod			Test Weight (g)		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	$CaCl_2$ 2% SH	26.53	28.33	27.43	7.27	7.70	7.48	10.47	10.53	10.50	50.77	51.20	50.98
T_2	CCC 500 mg/L SH	25.00	26.20	25.60	7.07	7.57	7.32	10.27	10.20	10.23	50.40	50.60	50.50
T_3	CCC 1000 mg/L SH	26.13	28.13	27.13	7.27	7.60	7.43	10.33	10.47	10.40	50.63	51.10	50.87
T_4	NAA 25 mg/L SH	24.47	25.87	25.17	7.07	7.50	7.28	10.00	10.20	10.10	49.50	50.30	49.90
T_5	NAA 50 mg/L SH	25.93	27.33	26.63	7.20	7.60	7.40	10.27	10.47	10.37	50.43	51.00	50.72
T_6	$CaCl_2$ 1% spraying at 30 DAS	29.93	32.00	30.97	7.80	7.83	7.82	11.00	11.17	11.08	52.23	52.47	52.35
T_7	CCC 500 mg/L spraying at 30 DAS	27.80	30.60	29.20	7.53	7.73	7.63	10.73	10.80	10.77	51.50	51.93	51.72
T_8	CCC 1000 mg/L spraying at 30 DAS	29.13	31.33	30.23	7.73	7.80	7.77	11.00	11.00	11.00	51.90	52.20	52.05
T_9	NAA 25 mg/L spraying at 30 DAS	27.27	29.07	28.17	7.47	7.73	7.60	10.60	10.73	10.67	50.93	51.77	51.35
T_{10}	NAA 50 mg/L spraying at 30 DAS	28.67	30.60	29.63	7.73	7.77	7.75	10.80	11.00	10.90	51.50	52.20	51.85
T_{11}	$CaCl_2$ 2% SH + 1% spraying at 30 DAS	33.73	35.67	34.70	8.40	8.50	8.45	11.87	12.00	11.93	53.77	53.83	53.80
T_{12}	CCC 500 mg/L SH + spraying at 30 DAS	31.60	33.67	32.63	8.13	7.93	8.03	11.27	11.60	11.43	52.83	52.97	52.90
T_{13}	CCC 1000 mg/L SH + spraying at 30 DAS	32.80	34.93	33.87	8.33	8.47	8.40	11.73	11.93	11.83	52.93	53.37	53.15
T_{14}	NAA 25 mg/L SH + spraying at 30 DAS	31.00	33.07	32.03	8.07	7.90	7.98	11.13	11.53	11.33	52.70	52.90	52.80
T_{15}	NAA 50 mg/L SH + spraying at 30 DAS	32.13	34.47	33.30	8.27	8.40	8.33	11.33	11.80	11.57	52.87	53.20	53.03
T_{16}	Absolute Control	22.00	23.33	22.67	6.93	7.27	7.10	9.60	9.87	9.73	49.07	49.47	49.27
	S.Em. ±	1.87	2.02	1.23	0.35	0.25	0.20	0.56	0.52	0.35	1.36	1.54	0.92
	C.D. @ 5%	5.39	5.84	3.48	NS	NS	0.56	NS	NS	0.97	NS	NS	2.60
	C.V. %	11.39	11.56	11.49	7.85	5.64	6.81	9.06	8.24	8.65	4.57	5.14	4.86

Table 4: Effect of seed hardening, foliar spraying and their combined effect on Seed yield and Harvest Index at harvest

Treat. No.	Treatment Details	Seed Yield/plant (g $plant^{-1}$)			Seed Yield/ha (kg ha^{-1})			Harvest Index (%)		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	$CaCl_2$ 2% SH	10.00	11.20	10.60	741	769	755	28.33	27.84	28.08
T_2	CCC 500 mg/L SH	9.47	10.60	10.03	697	737	717	27.93	27.36	27.65
T_3	CCC 1000 mg/L SH	9.87	11.00	10.43	721	761	741	28.24	27.70	27.97
T_4	NAA 25 mg/L SH	9.00	10.33	9.67	674	701	688	27.15	27.05	27.10
T_5	NAA 50 mg/L SH	9.60	10.87	10.23	702	752	727	27.91	27.68	27.80
T_6	$CaCl_2$ 1% spraying at 30 DAS	11.00	12.20	11.60	799	845	822	29.04	28.55	28.80
T_7	CCC 500 mg/L spraying at 30 DAS	10.47	11.60	11.03	764	800	782	28.61	28.07	28.34
T_8	CCC 1000 mg/L spraying at 30 DAS	10.80	12.07	11.43	779	831	805	28.84	28.49	28.66
T_9	NAA 25 mg/L spraying at 30 DAS	10.13	11.33	10.73	745	785	765	28.21	27.80	28.01
T_{10}	NAA 50 mg/L spraying at 30 DAS	10.53	11.80	11.17	765	825	795	28.48	28.21	28.35
T_{11}	$CaCl_2$ 2% SH + 1% spraying at 30 DAS	13.07	14.20	13.63	949	1006	978	30.50	29.80	30.15
T_{12}	CCC 500 mg/L SH + spraying at 30 DAS	12.13	13.27	12.70	860	880	870	29.82	29.15	29.49
T_{13}	CCC 1000 mg/L SH + spraying at 30 DAS	12.60	13.93	13.27	922	964	943	30.25	29.76	30.01
T_{14}	NAA 25 mg/L SH + spraying at 30 DAS	11.80	12.93	12.37	835	866	851	29.65	28.90	29.27
T_{15}	NAA 50 mg/L SH + spraying at 30 DAS	12.47	13.60	13.03	893	917	905	30.18	29.50	29.84
T_{16}	Absolute Control	8.07	9.40	8.73	639	679	659	26.78	26.91	26.84
	S.Em. ±	0.59	0.56	0.36	55.36	55.94	35.29	1.21	1.02	0.71
	C.D. @ 5%	1.70	1.61	1.02	160	162	100	NS	NS	2.01
	C.V. %	9.51	8.10	8.77	12.29	11.82	12.05	7.32	6.25	6.81

of seeds per plant, 1000-seed weight and thereby seed yield. The increase in the higher yield may be due to better carbon assimilation, better accumulation of carbohydrates and reduced respiration in plants. These results are in agreement with the findings of Mahabir singh and Rajodia (1989) in soybean, Singh and Dohare (1964), Das and Prusty (1982) and Pothalkar (2007) in pigeon pea. The present studies also indicated that growth regulators were very effective in increasing yield and yield attributes as compared to control.

The present study also indicated that seed hardening + spraying, only foliar spraying and only seed hardening treatments with $CaCl_2$, CCC and NAA significantly increased the number of pods per plant, seed yield per plant, 1000-seed weight and harvest index, which are most important yield determining components in green gram. The increase in seed yield with respect to above treatments was probably due to maximum water absorbing capacity of seeds, more intense photosynthetic activity and more tissue hydration and thereby enabling the plant to resist soil moisture stress more efficiently. This is in conformity with the findings of Mehrotra *et al.*, 1970 in okra, Arjunan and Srinivasan, 1989 in groundnut, Masood Ali (1985) in chickpea, Sen and Misra (1987) in wheat, Patil (1987) in sorghum, Shinde *et al*., (1991) in cowpea, Singh *et al*., (1991) in chickpea, Bora and Sarma (2005) in pea, Shinde and Jadhav (1995) in pigeonpea, Amaregouda *et al.,* (1994) in wheat, Jirali (2001) in turmeric and Prabhu (2000) in black gram.

CONCLUSION

Based on the above results, it is inferred that the yield potential in green gram can be improved by using plant growth regulators and agrochemical. The results also indicated a significant improvement in morpho-physiological traits, growth parameters, biochemical constituents and thereby yield due to the application of PGR's and agrochemical. Among the different treatments, seed hardening with 2% $CaCl_2$ + 1% foliar spraying at 30 DAS treatment significantly improved the most of morpho-physiological parameters and thereby yield in green gram followed by the seed hardening treatments of Cycocel 1000 mg/L + foliar spraying at 30 DAS and seed hardening with NAA 50 mg/L + foliar spraying at 30 DAS.

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