"SEED HARDENING, FOLIAR SPRAYING AND THEIR COMBINED EFFECT ON YIELD AND YIELD ATTRIBUTES OF GROUNDNUT (*Arachis hypogaea* L.)IN DIFFERENT SEASONS"

Comment [AK1]: Only yield and its attributes of Groundnut

ABSTRACT

The experiment was conducted during the summer and *kharif* seasons of 2022 using a Factorial Randomized Block Design with three replications. The study examined two factors: seed hardening, with nine levels, and foliar application ofChlorocholine chloride (CCC) at a concentration of 500 mg/L, with two levels. Results indicated that the treatment involving seed hardening with GA_3 at 100 mg/L, combined with the foliar application of CCC, led to a significant increase in the number of pods per plant, pod yield per plant, seed yield per plant, seed yield per hectare, and harvest index. Conversely, the control, which did not receive any seed hardening or CCC treatment, showed the lowest performance in all measured traits, highlighting the importance of these interventions in maximizing crop yield.

Keywords: GA_3, CCC, Seed hardening, Pod yield, Seed yield, Harvest index

INTRODUCTION

Comment [AK2]: Introduction should be short and comprehensive.

Groundnut (*Arachis hypogaea* L.) is popularly known as peanut, a self-pollinated crop and allotetraploid. It is a member of the order fabales and family Fabaceae. It is regarded as it ranks 13th among the principal economic crops. It is also called as wonder nuts, earth nuts, monkey nuts, goobers, pindea, manilla nuts and poor men's cashew nut (Ghadiya*et al.*, 2014).

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in many areas of the world, including the tropical, subtropical and warm temperate regions and now being cultivated on about 25 million hectares of land in about 100 countries in the world, under different agro-climatic regions where rainfall during the growing season exceeds 500 mm. On a global basis, 41 % of the production goes for food use and 49 % for extraction of edible oil. The remaining 10 % is used as feed and seed or goes waste(Singh and Nigam, 2016). According to the second advance estimates 2023-24, Government of India groundnut (*kharif* and rabi) crop is at 86.54 lakh tonnes as compared to 102.87 lakh tonnes in 2022-23. Among the states, Gujarat is leading in groundnut production with 36.74 lakh tonnes followed by Rajasthan (20.86 lakh tonnes), Madhya Pradesh (9.09 lakh tonnes), Tamil Nadu (7 lakh tonnes), Karnataka (3.69 lakh tonnes) and Telangana (1.98 lakh tonnes) (Anonymous, 2024).

Groundnut is also known as "KING OF OILSEEDS CROPS" on account of its diversified uses for food, feed, fodder and industrial purpose. It is valued as a rich source of energy contributed by oil (48–50%) and protein (25–28%) in the kernels. In addition, the groundnut kernels contain many health enhancing nutrients such as minerals such as K, Na, Ca, Mn, Fe, and Zn among others, antioxidants, and vitamins and also rich in mono-unsaturated fatty acids. They contain antioxidants like p-coumaric acid and resveratrol, Vitamin E, and many important B-complex groups of thiamine, pantothenic acid, vitamin B6, folates, and niacin. Groundnut is a dietary source of biologically active polyphenols, flavonoids, and isoflavones. As they are highly nutritious, groundnut and products based on groundnut can be promoted as nutritional foods to fight energy, protein, and micronutrient malnutrition among the poor (Janila *et al.*, 2013).

Groundnut cultivation in India spans all three primary agricultural seasons: *kharif*, *rabi* and *summer*, primarily under rainfed conditions. Among these seasons, *kharif* cultivation alone constitutes a substantial 75% share of the total groundnut production (Barman *et al.*, 2017).

The soil and climatic constraints affect the production resulted into wide variation and instability in yields. The low productivity of rainfed crops is a result of abiotic and biotic factors including cultural or agronomical like germination problems, soil quality constraints, poor fertility, scarcity of water, poor quality of water, high weed infestation etc. These constraints affect the production resulted into wide variation and instability in crop yields (Jain *et al.*, 2022).The low productivity of crops in rainfed areas is contributed by the use of poor-quality seeds. The features like rapid and identical seedling emergence are the two essential prerequisites to increase seed yield and seed quality in a number of field crops (Krishnotar*et al.*, 2009).

The hardening resulting from pre-sowing treatments is due to a number of physio-chemical changes within the cytoplasm including greater hydration of colloids, higher viscosity and elasticity of the protoplasm, increase in hydrophilic and decrease in lipophilic colloids, increase in the temperature required for protein coagulation and increase in bound water content (Solamalai and Subburamu, 2004). Seed hardening accelerated rapid germination, better root development and rapid growth of seedlings which enables absorption of more moisture. It induces drought tolerance by increasing the resistance to protoplasmic dehydration in young seedlings subjected to moisture stress. Flowering is also slightly accelerated in hardened seeds (Jain *et al.*, 2022).

Plants developed from hardened seeds often exhibit a faster growth due to an improved nutrient use efficiency besides higher relative growth rate. It is a well-established fact that, pre-soaking seeds with optimal concentration of phytohormones enhance their germination, growth and yield of some crop species under condition of environmental stress by increasing nutrient reserves through increased physiological activities and root proliferation (Bozeuk, 1981).

1. METHODOLOGY

a. Experimental Site

The experiment is conducted at Regional Research Station, Anand Agricultural University, Anand, India during Summer and *kharif*, 2022.

b. Treatment Details

The study included eighteen treatment combinations with nine levels of seed hardening treatments and two degrees of foliar spray. As an outcome, three replications of a factorial randomized block design involving eighteen treatment combinations with two different variables were included. Here are the treatment details along with their respective symbols.

Factor-1: Seed Hardening (A)

A1 : $CaCl_2$1%
A2 : Ethrel-50 mg/L
A3 : Ethrel-100 mg/L
A4 : Ethrel-150 mg/L
A5 : GA_3-50 mg/L
A6 : GA_3-100 mg/L
A7 : GA_3-150 mg/L
A8 : Soaking in water
A9 : Control

Comment [AK3]: Would be mentioned in running text.

Factor-2: Foliar Spray (B)

B1: Control no foliar spray
B2: CCC @500 mg/L

*Foliar spray of CCC was given at 35 and 55 DAS in all treatments

Table 1 Details of treatment combinations

Sr. No.	**Treatment**	**Treatment combinations details**
1	A1B1	$CaCl_2$1% seed hardening + Control (No foliar spray)
2	A2B1	Ethrel-50 mg/L seed hardening + Control (No foliar spray)
3	A3B1	Ethrel-100 mg/L seed hardening + Control (No foliar spray)
4	A4B1	Ethrel-150 mg/L seed hardening + Control (No foliar spray)
5	A5B1	GA_3-50 mg/L seed hardening + Control (No foliar spray)
6	A6B1	GA_3-100 mg/L seed hardening + Control (No foliar spray)
7	A7B1	GA_3-150 mg/L seed hardening + Control (No foliar spray)
8	A8B1	Soaking in water seed hardening + Control (No foliar spray)
9	A9B1	Control (Without hardening) + Control (No foliar spray)
10	A1B2	$CaCl_2$1% seed hardening + CCC 500 mg/L foliar spray
11	A2B2	Ethrel 50 mg/L seed hardening + CCC 500 mg/L foliar spray
12	A3B2	Ethrel 100 mg/L seed hardening + CCC 500 mg/L foliar spray
13	A4B2	Ethrel 150 mg/L seed hardening + CCC 500 mg/L foliar spray
14	A5B2	$GA_3$50 mg/L seed hardening + CCC 500 mg/L foliar spray
15	A6B2	$GA_3$100 mg/L seed hardening + CCC 500 mg/L foliar spray
16	A7B2	$GA_3$150 mg/L seed hardening + CCC 500 mg/L foliar spray
17	A8B2	Soaking in water seed hardening + CCC 500 mg/L foliar spray
18	A9B2	Control (Without hardening) + CCC 500 mg/L foliar spray

c. Methods of Seed Hardening and Foliar Application of Growth Substances

$CaCl_2$ 1% was prepared by dissolving 10 g of $CaCl_2$ in 1 liter of distilled water. Ethrel-50 mg/L, Ethrel-100 mg/L and Ethrel-150 mg/L were prepared by dissolving 50, 100 and 150 mg of Ethrel in one liter of water respectively. GA_3-50 mg/L, GA_3-100 mg/L and GA_3-150 mg/L were prepared by dissolving 50, 100 and 150 mg of GA_3 in one liter of water respectively.

Seed hardening treatments were applied to Groundnut seeds, soaking them in double volume solutions for four hours to prevent germination. After drying, seeds were ready for sowing in the field and under laboratory conditions, ensuring their original moisture level.

This experiment uses Chlorocholine Chloride (CCC) as a foliar spray. A stock solution of 50% CCC was prepared, and a final solution of 10 liters was prepared. Spraying was carried out at 35 and 55 DAS in respective plots during both seasons.

2.4 Yield Parameters

2.4.1 Number of Pods/Plant

Comment [AK4]: Would be mentioned in running text.

Comment [AK5]: No need to mentioned about combination. Only need to mentioned about interaction of A and B.

Comment [AK6]: Description for parameters should be short and in running text.

Number of pods/plantwere counted from five randomly tagged plants and recorded separately for each net plot and finally average pods per plantin each treatment was worked out and recorded separately.

2.4.2Pod yield per plant (g)

The five randomly tagged plants were uprooted at maturity and weighed for pod yield from which the average was calculated and expressed as pod yield per plant.

2.4.3 100 kernels weight (g)

A composite sample of kernels was drawn from shelled pods of each net plot and 100 kernels were counted and weighed and recorded separately for each plot.

2.4.4 Seed yield per plant (g)

The five randomly tagged plants were uprooted at maturity and processed for seed yield from which the average was calculated and expressed as seed yield per plant.

2.4.5 Seed yield per hectare (kg)

The plants harvested from net plot were threshed, clean, sun dried for five days and then grain weight per plot was recorded separately for each treatment. This was further converted on hectare basis.

2.4.6 Shelling percentage (%)

The shelling percentage of groundnut was measured by taking 100 grams of dried pods from each net plot. The kernels were manually separated from shell and weight of kernels was measured in grams. Then the shelling percentage was calculated by using following formula:

$$\text{Shelling percentage (\%)} = \frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100$$

2.4.7 Harvest index (%)

The harvest index is the ratio of economic yield to biological yield. The harvest index was computed by using formula suggested by Donald and Hamblin (1976) and recorded for each treatment.

$$\text{HI (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

2. RESULT AND DISCUSSION

Comment [AK7]: More research finding would be discussed. B:C ratio would be discuss for more adaptability of findings.

3.1 Effect of seed hardening on yield characters

3.1.1 Effect of seed hardening on number of pods per plant

Comment [AK8]: Would b changed be **Seed hardening on number of pods per plant in each. Result and discussion would be in running text.**

The data (Table 2) regarding number of pods per plant (38.61) showed that significantly higher with ethrel-100 mg/L seed hardening (A3)during the summer, 2022 which was statistically at par with A6, GA_3-100 mg/L seed hardening (35.66)during summer, 2022. Meanwhile, maximum number of pods per plant was observed in A6, GA_3-100 mg/L treated seed hardening (34.63 and 35.14) during *kharif*, 2022 and pooled means.

Greater availability of photosynthate, metabolites and nutrients to develop reproductive structures seems to have resulted in increased number of pods per plant.

3.1.2 Effect of seed hardening onpod yield per plant

The significantly (Table 2) higher pod yield per plant (36.91, 36.57 and 36.4 g/plant) was recorded with GA_3-100 mg/L (A7) in both the seasons, 2022 and pooled data, respectively.

3.1.3 Effect of seed hardening on 100 kernels weight

Maximum 100 kernels weight was observed in ethrel-100 mg/L seed hardening (49.77 g) during summer, 2022. During *kharif* season, ethrel-50 mg/L seed hardening (49.34g) showed maximum 100 kernels weight. Meanwhile, ethrel-100 mg/L seed hardening(49.23 g) noted higher 100 kernels weight during pooled result.

The probable reasons for improvement in yield attributes number of pods per plant, pod yield per plant, number hundred kernels weight might be due to the hardening treatments which accelerate the synthesis of protein and nucleic acid, bound water content, repair mechanism and growth of seedling resulting in increasing uptake of nutrients and ability of treated plants to unfavourable condition when compared to control.

3.1.4 Effect of seed hardening on seed yield per plant

Seed yield per plant as influenced by seed hardening during two consecutive seasons, 2022 and in pooled mean is depicted in Table3. Seed yield per plant (21.32, 8.72 and 19.97 g/plant) recorded significantly higher with GA_3-100 mg/L (A6)during summer and *kharif*, 2022 and in pooled results, respectively.

3.1.5Effect of seed hardening on seed yield per ha

The significantly higher seed yield per hectare (2419.80, 2090.24 and 2255.02 kg/ha) was recorded with GA_3-100 mg/L (A6) in the summer and *kharif*, 2022 and pooled data, respectively (Table 3).

The increased seed yield may be attributed to higher dry matter production and its partition in reproductive parts so increased yield components mainly 100 seeds weight, seed yield per plant. 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 recorded by Henckel (1964).

3.1.6Effect of seed hardening on shelling percentage

Data shown in Table 3 indicated that the effect of seed hardening on shelling percentage during summer and *kharif*, 2022 and in pooled results was found to be non-significant. Although higher shelling percentage was found in $CaCl_2$ 1% (71.97 %) during summer while GA_3-100 mg/L seed hardening showed higher shelling percentage (67.34 and 67.49 %) during *kharif* and pooled basis respectively.Higher shelling percentage represented higher seed yield which is important yield component.

3.1.6 Effect of seed hardening on Harvest index

An examination of data given in Table 3 indicated that the significantly higher harvest index (31.07, 25.54 and 28.30 %) was recorded with GA_3-100 mg/L seed hardening treatment (A6) in the both seasons, 2022 and pooled data, respectively.

This could probably be due to beneficial effects of plant growth substance treatments as seed hardening which helps in enhancement of photosynthesis and nitrogen metabolism which are the major physiological process influencing plant growth and development.

Table 2 Effect of seed hardening and foliar spray on number of pods per plant, pod yield per plant and 100 kernels weight in groundnut summer and *kharif*, 2022 as well as in pooled analysis

	Number of Pods/Plant			Pod Yield/Plant (g)			100 Kernels Weight (g)		
	Summer	***kharif***	**Pooled**	**Summer**	***kharif***	**Pooled**	**Summer**	***kharif***	**Pooled**
Seed Hardening (A)									
A1	35.09	33.74	34.42	30.70	28.81	29.76	48.35	45.77	47.06
A2	34.84	33.99	34.41	35.73	29.51	32.62	48.62	49.34	48.98
A3	38.61	30.52	34.56	36.08	27.52	31.80	49.77	48.69	49.23
A4	32.63	29.46	31.05	35.59	31.06	33.32	44.63	40.43	42.53
A5	34.62	29.90	32.26	32.64	30.67	31.65	44.00	43.50	43.75
A6	35.66	34.63	35.14	36.91	36.57	36.74	47.01	44.71	45.86
A7	32.90	31.33	32.12	32.21	31.92	32.07	45.73	41.86	43.80
A8	32.12	28.92	30.52	27.15	23.62	25.38	45.02	41.34	43.18
A9	31.11	27.33	29.22	26.16	25.14	25.65	41.63	41.27	41.45
S.Em.(±)	1.430	1.147	0.917	1.107	0.938	0.725	1.429	0.828	0.826
C.D. $_{(0.05)}$	4.110	3.298	2.587	3.180	2.695	2.046	4.107	2.379	2.330
Foliar Spray (B)									
B1	31.85	28.78	30.31	28.65	25.57	27.11	41.91	40.48	41.19
B2	37.39	34.38	35.89	36.50	33.28	34.89	50.26	47.72	48.99
S.Em.(±)	0.674	0.541	0.432	0.522	0.442	0.342	0.674	0.390	0.389
C.D. $_{(0.05)}$	1.937	1.555	1.219	1.499	1.270	0.965	1.936	1.121	1.098
Interaction									
AxS	-	-	**NS**	-	-	**Sig.**	-	-	**Sig.**
BxS	-	-	**NS**	-	-	**NS**	-	-	**Sig.**
AxB	**NS**	**NS**	**NS**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**NS**	**Sig.**
AxBxS	-	-	**NS**	-	-	**NS**	-	-	**NS**
C.V.(%)	**10.12**	**8.90**	**9.59**	**8.32**	**7.81**	**8.10**	**7.60**	**4.60**	**6.34**

Comment [AK9]: Mean value of interaction would be mentioned in table.

3.2 Effect of foliar spray of CCC on yield characters

3.2.1 Effect of foliar spray of CCC on number of pods per plant

Number of pods per plant (Table 2) was recorded significantly higher (37.49, 34.38 and 35.89) with foliar spraying of CCC @500 mg/L (B2) during summer and *kharif*, 2022 as well as in pooled results, respectively.In the present study, it is revealed that the application of CCC significantly increased number of pods per plant and finally kernel yield per plant which is the most important yield determining components in groundnut.

The increased number of pods per plant might be due to reduction in flower drop which resulted in retention in greater number of sinks (Resmi and Gopalkrishnan, 2004). Similar result was obtained by Singh and Jambukiya (2020).

3.2.2 Effect of foliar spray of CCC on pod yield per plant

The data indicated that the significantly higher pod yield per plant (36.50, 33.28 and 34.89 g/plant) was recorded with foliar spraying of CCC @500 mg/L (B2) during both the seasons and in pooled analysis, respectively.

The increase in the pod yield by application of CCC might be due to reduced plant height and increased branching resulting in diversion of food material for the improvement of flowering and fruiting. The result is accordance with Singh *et. al.* (2018) in field pea as well as with Singh and Jambukiya (2020) in groundnut.

3.2.3 Effect of foliar spray of CCC on 100 kernels weight

Maximum 100 kernels weight (50.26, 47.72 and 48.99 g) was observed with foliar spraying of CCC @500 mg/L (B2) during summer-2022, *kharif*-2022 and pooled basis.

3.2.4 Effect of foliar spray of CCC on seed yield per plant

Seed yield per plant (Table 3) was recorded significantly higher (22.19, 19.06 and 2.63 g/plant) with foliar spray of CCC @500 mg/L (B2) during summer and *kharif*, 2022 as well as in pooled results, respectively.

The increased seed yield may be attributed to higher dry matter production and its partition in reproductive parts so increased yield components mainly pod yield per plant, 100 kernels weight and seed yield per plant. The result is in accordance with Prajapati *et al.*, 2017 in black gram.

3.2.5 Effect of foliar spray of CCC on seed yield per ha

The data presented in Table 3 indicated that the significantly higher seed yield per hectare (2485.11, 2132.83 and 2308.97 kg/ha) was recorded with foliar spraying @500 mg/L (B2) during both the seasons and in pooled analysis, respectively.

CCC sprayed groundnut plants often exhibit a stronger source-sink relationship. This means that there is a more efficient flow of photosynthates from leaves to developing seeds, leading to higher dry matter partitioning and seed yield. CCC can optimize nutrient use efficiency in groundnut plants, directing more nutrients towards reproductive processes, such as seed development. This improved nutrient utilization contributes to higher seed yield. Singh and Jambukiya (2020) also noted that seed yield/ha was increased with the foliar spray of CCC in green gram.

Table 3 Effect of seed hardening and foliar spray on seed yield per plant, seed yield per ha, shelling percentage and harvest index in groundnut summer and *kharif*, 2022 as well as in pooled analysis

	Seed Yield per Plant (g)	Seed Yield per ha (kg)	Shelling Percentage (%)	Harvest Index (%)

	Summer	*kharif*	Pooled	Summer	*kharif*	Pooled	Summer	*kharif*	Pooled	Summer	*kharif*	Pooled
Seed Hardening (A)												
A1	20.69	16.20	18.45	2065.99	1663.49	1864.74	71.97	58.91	65.44	29.09	23.09	26.09
A2	21.22	16.95	19.14	2176.67	1856.73	2016.70	62.05	62.34	62.20	29.79	23.64	26.71
A3	20.49	16.81	18.65	2160.60	1800.84	1980.72	63.30	62.30	62.80	28.40	22.90	25.65
A4	19.35	17.22	18.29	2303.83	1970.85	2137.34	66.37	66.15	66.26	29.25	22.05	25.65
A5	20.25	16.42	18.33	2265.22	1917.50	2091.36	62.93	62.68	62.81	29.34	22.77	26.05
A6	21.32	18.72	19.97	2419.80	2090.24	2255.02	67.64	67.34	67.49	31.07	25.54	28.30
A7	16.47	17.97	17.22	2324.23	2066.53	2195.38	66.39	66.97	66.68	30.28	24.32	27.30
A8	18.08	15.95	17.01	2112.11	1785.57	1948.84	63.74	62.88	63.31	29.39	25.44	27.42
A9	19.90	14.38	17.14	1982.68	1688.91	1835.79	55.77	57.76	56.77	28.15	21.89	25.02
S.Em.(±)	0.512	0.454	0.342	70.095	56.529	45.025	3.163	3.271	2.275	0.590	0.547	0.402
C.D.$_{(0.05)}$	1.470	1.305	0.965	201.454	162.466	127.060	NS	NS	NS	1.696	1.573	1.136
Foliar Spray (B)												
B1	17.31	14.41	15.86	1917.36	1609.54	1763.45	61.58	59.27	60.42	28.36	22.42	25.39
B2	22.19	19.06	20.63	2485.11	2132.83	2308.97	67.35	66.80	67.08	30.47	24.61	27.54
S.Em.(±)	0.241	0.214	0.161	33.043	26.648	21.225	1.491	1.542	1.073	0.278	0.258	0.190
C.D.$_{(0.05)}$	0.693	0.615	0.455	94.966	76.587	59.897	4.286	4.432	3.027	0.799	0.741	0.535
Interaction												
AxS	**-**	**-**	**Sig.**	**-**	**-**	**Sig.**	**-**	**-**	**NS**	**-**	**-**	**NS**
BxS	**-**	**-**	**Sig.**	**-**	**-**	**Sig.**	**-**	**-**	**NS**	**-**	**-**	**NS**
AxB	**Sig.**	**Sig.**	**Sig.**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
AxBxS	**-**	**-**	**NS**	**-**	**-**	**NS**	**-**	**-**	**NS**	**-**	**-**	**NS**
C.V.(%)	**6.34**	**6.65**	**6.49**	**7.80**	**7.40**	**7.66**	**12.02**	**12.71**	**12.36**	**4.91**	**5.70**	**5.27**

Comment [AK10]: S=significant and NS=Non Significant would be mentioned as abbreviation below table.

3.2.6 Effect of foliar spray of CCC on shelling percentage

Resultindicated that the effect of foliar spray exerts significant effect on shelling percentage during summer and *kharif*, 2022 and in pooled results. Higher shelling percentage was observed in foliar spray of CCC @500 mg/L (67.35, 66.80 and 67.08 %) during summer, *kharif*-2022and pooled result as compared to control (B1).

CCC can improve shelling percentage by increasing the number of pods per plant, reducing lodging (falling over of plants), and promoting uniform pod development. These effects can lead to easier harvesting and higher shelling percentages.

3.2.7 Effect of foliar spray of CCC on Harvest index

The result indicated that the significantly higher harvest index (30.47, 24.61 and 27.54 %) was recorded with foliar spraying of CCC @500 mg/L (B2) during both the seasons and in pooled analysis, respectively. The harvest index represents the proportion of total biomass allocated to the harvestable yield relative to the total biomass. CCC reduces total biomass and increase pod yield by diverting photosynthates to pod development which ultimately leads to increase in harvest index.

3.3 Interaction effect of seed hardening and foliar spray of CCC on yield characters

3.3.1 Interaction effect of seed hardening and foliar spray of CCC on number of pods per plant

Interaction effect of seed hardening and foliar spraying with CCC (A×B) was found non-significant with respect to number of pods per plant during both seasons and pooled basis.

3.3.2 Interaction effect of seed hardening and foliar spray of CCC on pod yield per plant (g)

Data shown in Table 4 showed that the interaction effect of seed hardening and foliar spray on pod yield per plant was found to be significant during both the summer and *kharif*, 2022 and pooled results.The combine application of GA_3-100 mg/L with foliar spraying with CCC @ 500 mg/L (A6B2) recorded significantly higher pod yield per plant (36.71, 34.93 and 35.82 g/plant) during the summer-2022, *kharif*-2022 and pooled result respectively.

3.3.3 Interaction effect of seed hardening and foliar spray of CCC on 100 kernels weight (g)

An examination of results given in Table 5 indicated that the interaction effect of seed hardening and foliar spray on 100 kernels weight was found significant during summer and pooled analysis. Seed hardening with ethrel-100 mg/L and foliar spray of CCC@ 500 mg/L (A3B2) recorded higher 100 kernels weight (50.02 and 49.11 g) as compared to other treatment combination during summer and pooled basis.

3.3.4 Interaction effect of seed hardening and foliar spray of CCC on Seed yield per plant (g)

Interaction effect (Table 6) of seed hardening and foliar spray (A×B) was found significant with respect to seed yield per plant during both seasons, 2022 and in pooled results. Significantly higher seed yield per plant (21.71, 18.89 and 20.30g) was noted in treatment combination of GA_3-100 mg/L seed hardening and foliar spray of CCC @500 mg/L (A6B2) during summer, *kharif*-2022 and pooled analysis. Similar result was found by Singh *et al.* (2018).

3.3.5 Interaction effect of seed hardening and foliar spray of CCC on Seed yield per ha (kg)

The interaction effect between seed hardening and foliar spray of CCC @500 mg/L (A×B) for seed yield per hectare was found non-significant duringthe summer and *kharif*, 2022 and in pooled results.

Table 4 Interaction effect between seed hardening and foliar application on pod yield/plant during summer and *kharif*, 2022 and in pooled analysis

Pod yield per Plant (g)						
	Summer, 2022		***Kharif*, 2022**		**Pooled**	
	B1	B2	B1	B2	B1	B2
A1	29.68	33.6	27.19	31.05	28.44	32.32
A2	32.19	36.12	27.54	31.40	29.87	33.76
A3	32.37	36.29	26.55	30.40	29.46	33.35
A4	32.12	36.05	28.32	32.17	30.22	34.11
A5	30.65	34.57	28.12	31.98	29.39	33.27
A6	32.78	36.71	31.07	34.93	31.93	35.82
A7	30.94	34.36	29.56	32.60	30.25	33.48
A8	27.90	31.83	24.61	28.45	26.25	30.14
A9	27.41	31.33	25.36	29.21	26.38	30.27
S.Em(±)	**1.565**		**1.326**		**1.026**	
$CD_{(0.05)}$	**4.498**		**3.811**		**2.894**	
CV (%)	**8.32**		**7.81**		**8.10**	

Table 5 Interaction effect between seed hardening and foliar application on 100 kernel weight during summer, 2022 and in pooled analysis

100 Kernels Weight (g)				
	Summer, 2022		**Pooled**	
A×B	B1	B2	B1	B2
A1	45.13	49.31	44.13	48.03
A2	45.27	49.44	45.09	48.99
A3	45.84	50.02	45.21	49.11
A4	43.27	47.45	41.86	45.76
A5	42.96	47.13	42.47	46.37
A6	44.46	48.64	43.53	47.43
A7	45.43	48.00	43.96	46.40
A8	41.77	45.95	41.34	45.24
A9	43.47	47.64	42.17	46.07
S.Em(±)	**2.021**		**1.168**	
$CD_{(0.05)}$	**5.808**		**3.295**	
CV (%)	**7.60**		**6.34**	

3.3.6 Interaction effect of seed hardening and foliar spray of CCC on Shelling Percentage (%)

Interaction effect of seed hardening and foliar spray of CCC was found non-significant with respect to shelling percentage during individual season as well as pooled results.

3.3.7 Interaction effect of seed hardening and foliar spray of CCC on Harvest Index (%)

Interaction effect of seed hardening and foliar spraying of CCC (A×B) was found non-significant with respect to harvest index during individual season as well as pooled basis.

Table 6 Interaction effect between seed hardening and foliar application on seed yield/plant during summer and *kharif*, 2022 and in pooled analysis

Seed Yield per Plant (g)						
	Summer, 2022		*Kharif*, 2022		Pooled	
A×B	B1	B2	B1	B2	B1	B2
A1	19	21.44	15.31	17.63	17.15	19.54
A2	19.27	21.71	15.68	18.01	17.48	19.86
A3	18.9	21.34	15.61	17.94	17.26	19.64
A4	18.33	20.77	15.82	18.14	17.07	19.46
A5	18.78	21.22	15.42	17.74	17.1	19.48
A6	19.32	21.76	16.57	18.89	17.94	20.33
A7	17.74	19.33	16.64	18.52	17.19	18.92
A8	17.7	20.14	15.18	17.51	16.44	18.82
A9	18.61	21.05	14.4	16.72	16.5	18.89
S.Em(±)	**0.723**		**0.642**		**0.484**	
$CD_{(0.05)}$	**2.079**		**1.845**		**1.364**	
CV (%)	**6.34**		**6.65**		**6.49**	

4 CONCLUSION

Comment [AK11]: Acknowledgment would be written.

The results of the study showed that groundnuts could be treated with GA_3-100 mg/L seed hardening treatment and 500 mg/L of CCC applied topically to increase yield and factors related to yield, including number of pods per plant, pod yield per plant, seed yield per plant, seed yield per ha, shelling percentage, and harvest index. In summary, farmers who hoped to increase their yield were recommended to use GA_3 at 100 mg/L as seed hardening and 500 mg/L of ChlorocholineChloride (CCC) by foliar spraying.

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