The Pharma Innovation Journal 2023; 12(12): 2165-2168

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 2165-2168

www.thepharmajournal.com
Received: 02-10-2023
Accepted: 12-11-2023

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Influence of hydrogel application on growth, seed yield and quality in chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted to study the "Influence of Hydrogel application on growth, seed yield and quality in Chickpea (*Cicer arietinum* L)". Experiment was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka during *rabi* 2022-23. The chickpea is a significant *rabi* season pulse crop that is primarily grown in semi-arid and warm temperate parts of the world. The low average yield of chickpea in India can be attributed to its dependence on residual soil moisture during the cool dry season. Generally, the moisture level in the soil decreases gradually as the crop develops. Consequently, the plant faces escalating terminal moisture stress, which becomes a significant factor limiting chickpea growth and yield, especially in peninsular India. In this situation, the use of super absorbents or hydrogels has been found to be particularly efficient in improving the retention of applied water in the soil around the root zone by reducing percolation and evaporative losses, ensuring a better and longer supply of moisture to the crop. To evaluate the methods of hydrogel application in chickpea with eight treatments and three replications *viz.*, T_1 (control untreated), T_2 (Seed hardening with $CaCl_2$ @ 2 g/kg), T_3 (Seed treatment of @ Pusa hydrogel 2.5 kg/ha), T_4 (Seed treatment of SPG1118 @ 2.5 kg/ha), T_5 (Slurry treatment of Pusa hydrogel at 1:25 ratio), T_6 (Slurry treatment of SPG1118 @ 1:25 ratio), T_7 (Soil application of Pusa hydrogel at 5 kg/ha), T_8(Soil application of SPG 1118 @ 5 kg/ha). The results revealed that seed treatment with SPG1118 at 2.5 kg/ha recorded significantly higher number of secondary branches (15.67), test weight (27.78 g), seed germination (97.33%), root length (17.43 cm), shoot length (15.76 cm), seedling vigour index (3230), seed yield (17.57 q/ha) and net returns (₹ 55296 ha^{-1}) compared to other treatments.

Keywords: Seed treatment, hydrogel, seed quality and seed yield

Introduction
The chickpea (*Cicer arietinum* L.), an annual legume in the Fabaceae family, is a well-liked winter crop farmed for its typically yellow-brown, pea-like seeds. It is grown in tropical, subtropical and temperate locations and is among the third most important pulse crops in India because of its numerous functions in the prehistoric farming system. It has a protein content of 18 to 24%, which has more than that of cereals.

The low average yield of chickpea in India can be attributed to its dependence on residual soil moisture during the cool dry season. Generally, the moisture level in the soil decreases gradually as the crop develops. Consequently, the plant faces escalating terminal moisture stress, which becomes a significant factor limiting chickpea growth and yield, especially in peninsular India. This condition notably impacts the formation of pods, crucial for determining the crop yield potential (Manjunath *et al.*, 2011) [6]. Moreover, key physiological constraints on productivity include excessive flower shedding, inadequate pod filling, insufficient dry matter accumulation and pod shedding.

Abiotic stresses, such as moisture stress exert a notable influence on productivity. Endeavors to enhance yields by surmounting these limitations have demonstrated substantial advancements. While research predominantly delves into comprehending the mechanisms governing productivity, there exists a dearth of exploration into strategies for mitigating stresses or constraints posed by environmental elements.

In this situation, the use of super absorbents or hydrogels has been found to be particularly efficient in improving the retention of applied water in the soil around the root zone by reducing percolation and evaporative losses, ensuring a better and longer supply of moisture to the crop (Narjary *et al.*, 2015) [8].

Super Absorbent Polymers (SAPs) are substances that expand significantly in size and weight after absorbing water. They are networks of hydrophilic polymer chains that are only weakly cross-linked. The network can hold a lot of water while preserving its physical dimension structure. It may also swell in water. The partial neutralization products of cross-linked polyacrylic acids, the partial hydrolysis products of starch-acrylonitrile copolymers and the starch-acrylic acid graft copolymers are recognized to be the commercially used water-absorbent polymeric materials. They decay into ammonium, carbon dioxide and water throughout the course of their half-lives, which are typically between 5 and 7 years. The permeability, density, structure, texture, evaporation and infiltration rates of soils could all be impacted by the super absorbent polymer hydrogel. In particular, the hydrogels lessen the frequency of watering and the propensity for compaction, halt erosion and water runoff and improve soil aeration and microbial activity. Keeping the above views in mind, a study on "Influence of Hydrogel application on growth, seed yield and quality in Chickpea (*Cicer arietinum* L)" was undertaken.

Materials and Methods

Experiment was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka. Chickpea seeds were collected from the Seed Unit, University of Agricultural Sciences, Dharwad. Seeds were treated with 2% $CaCl_2$ as dry seed treatment as a check. Seeds were treated with hydrogels (Pusa hydrogel and SPG1118) at a rate of 2.5 kg/ha using binders and left to dry in the shade for 5-6 hours. Similarly, a 1:25 (hydrogel: water) ratio of hydrogels slurry was made and put in the seed furrows at the time of sowing. Soil application of both hydrogels were mixed with soil in 1:1 ratio and uniformly applied in the furrows at the time of sowing. All the treatments were timed in such a way that all of them would end at the same time. After imposing all the treatments, seeds were sown in main field. The plant height, number of branches, yield parameters and seed quality parameters were recorded.

Results and Discussion

The plant height at 30, 60 and 90 DAS was 26.2 cm 35.9 cm and 46.9 cm respectively, when seeds are coated with SPG1118 (2.5 kg/ha) hydrogel compare to other methods of application. The seed treatment of super absorbent helps in cell division, cell elongation and stem elongation which inturn enhances the vegetative growth of the plant. The coating with hydrogels to seeds at the time of sowing can potentially improve the water availability for the early growth and development of plants under dry conditions and therefore, prevent associated delays in the development of plant parts reported by Ismail *et al.* (2013) [74]. Similar findings were reported that plant height of maize and wheat increased with hydrogel application of 2.5 to 5 kg/ha reported by Islam *et al*. (2011) [3] and Roy *et al*. (2019) [10] respectively. The higher soil water availability as a result of hydrogel application helps to escape water stress during prolonged periods of water scarcity. During the phase of water release by the hydrogel, free pore volume will be set up within the soil, offering additional space for root growth and air and water infiltration and storage. It also strongly resists soil pressure at high soil depth without losing its swelling capacity. Concurrently, water is stored in the rhizosphere so that water and plant nutrient losses due to deep percolation and nutrient leaching can be ignored. In this way, water and nutrients can be made available to the plant for a long period.

There was a significant increase in number of secondary branches per plant was noticed in plots that were seed treated with SPG1118 (2.5 kg ha^{-1}) followed by seed treated with Pusa hydrogel (2.5 kg ha^{-1}). The data showed that seed treatment with SPG1118 at 2.5 kg/ha (T_4) produced higher seed yield (17.57 q ha^{-1}) followed by the (T_3) seed treatment with Pusa hydrogel at 2.5 kg/ha (17.19 q ha^{-1}). The increase of number of secondary branches per plant (15.7), number of pods per plant (65.40), test weight (27.78 g) and seed yield per hectare (17.57 q ha^{-1}). This increase in seed yield might be associated with the improved photosynthesis rate and leaf relative water content in plants under superabsorbent polymers would enhance growth under drought-stress conditions explained by Jarvis and Davies (1998) [5]. Hydrogel increase availability of nutrients like macro (N, P, K) as well as micronutrient (Mo, Zn and Mn) to the roots of crop which helps in turns to increase in photosynthetic activity of plants that later enhances the vegetative growth thus the number of leaves per plant, number of branches, plant height and root length (Sharma *et al.*, 2014) [11]. The water holding capacity of the soil, which maintains the soil moisture for a longer period, thus enhancing the microbial activity of the soil and preventing flower shedding, insufficient dry matter accumulation, Pattanaik *et al.* (2015) [9] in citrus.

Similar findings were repoted by Farjam *et al.* (2014) [2] increased the number of pods per plant, seed weight, and seed yield per unit area in chickpea. Tohidi *et al.* (2009) [12] reported that super absorbent polymer stores water in an effective way and under stress conditions, the moisture was applied to the plant and increased the growth and yield parameter. The polymer has the ability to increase water retention in soil which facilitates higher water uptake and water use efficiency, thus helping in reducing the water stress of plants and increasing crop growth and yield.

Application of SPG1118 at 2.5kg/ha recorded significantly higher gross returns (₹ 92,835 ha^{-1}), net return (₹ 55,296 ha^{-1}) and BC ratio (2.47) as compared to other treatments. Which is on par with the seed treatment with Pusa hydrogel at 2.5kg/ha recoded higher gross returns (₹ 90,638 ha^{-1}), net return (₹ 53,349 ha^{-1}) and BC ratio (2.43). The results are in accordance with Farjam *et al.* (2014) [2] in chickpea, Pattanaik *et al.* (2015) [9] in citrus and Tohidi *et al.* (2009) [12].

Ismail *et al.* [2013] [4] reported that the super absorbent hydrogel composed of acrylamide and acrylic acid on starch using polyethene glycol (PEG) has a positive effect on the germination of maize seeds and growth of young plants than seeds without hydrogel. Alternatively, hydrogel-treated plants show satisfactory effects for the fresh and dried weight of leaves and roots. Elshafie *et al.* [2020] [1] also experimented on the biological activity of some natural substances and/or antimicrobial hydrogels on the germination of seeds of *Phaseolus vulgaris* and concluded that the hydrogen gel-based oregano essential oil with the assistance of *Burkholderia gladioli* bacteria was superior in seed germinations. The seed quality parameters showed significant differences when chickpea seeds were treated with different quantity hydrogel. The positive effect was noted when seed treated with SPG1118 at 2.5kg/ha (T_4) recorded the higher germination (97%), root length (17.53 cm), shoot length (15.50 cm), seedling dry weight (248 mg), seedling vigour index-I (3203) compared control. The seed germination, seedling emergence and its vigour, stability of plant growth and yield can be guaranteed in drought stress when the soil is treated with super absorbent polymers (Montesano *et al*., 2015) [7]. The synergistic effect of hydrogel seed treatment improves enhancement in seed germination and seedling growth and integrated nutrient management ascribed to continuous supply of nitrogen and phosphorous to produce healthy plants and higher seed.

Table 1: Influence of methods of hydrogel application on seed quality parameters in chickpea

Treatments	Plant height	Secondary Branches/plant	Number of pods/plant	Test weight (g)	Seed yield (q/ha)	Seed recovery (%)
T_1-Control	38.9	11.85	51.92	24.90	14.74	93.20
T_2- Seed hardening with $CaCl_2$ @ 2 g/kg	41.5	12.87	55.16	25.74	15.53	95.53
T_3-Seed treatment of Pusa hydrogel @ 2.5 kg/ha	45.7	15.0	61.52	27.15	17.19	97.12
T_4 -Seed treatment of SPG1118 @ 2.5 kg/ha	46.9	15.67	65.40	27.78	17.57	97.82
T_5-Slurry treatment of Pusa hydrogel @ 1:25 ratio	43.1	13.10	56.01	26.11	16.36	95.69
T_6-Slurry treatment of SPG1118 @ 1:25 ratio	42.9	13.46	57.41	26.55	16.28	95.10
T_7-Soil application of Pusa hydrogel @ 5 kg/ha	45.1	14.86	60.48	26.93	16.89	96.87
T_8-Soil application of SPG 1118 @ 5 kg/ha	44.4	14.30	59.77	26.25	16.84	95.93
S.Em ±	0.25	0.19	0.95	0.19	0.13	0.20
CD (5%)	0.72	0.48	2.87	0.58	0.38	0.60

Table 2: Economics of seed production in chickpea as influenced by methods of hydrogel application

Treatments	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
T_1-Control	79001	44462	2.29
T_2- Seed hardening with $CaCl_2$ @ 2 g/kg	82843	48272	2.32
T_3-Seed treatment of Pusa hydrogel @ 2.5 kg/ha	90638	53349	2.43
T_4 -Seed treatment of SPG1118 @ 2.5 kg/ha	92835	55296	2.47
T_5-Slurry treatment of Pusa hydrogel @ 1:25 ratio	87301	50012	2.34
T_6-Slurry treatment of SPG1118 @ 1:25 ratio	86500	48961	2.30
T_7-Soil application of Pusa hydrogel @ 5 kg/ha	89945	50406	2.27
T_8-Soil application of SPG 1118 @ 5 kg/ha	89289	49750	2.26
S.Em ±	687	687	0.02
CD (5%)	2118	2118	0.06

Table 3: Influence of methods of hydrogel application on seed quality parameters in chickpea

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling dry weight (mg)	SVI-I
T_1-Control	90.33	14.50	13.57	195	2536
T_2- Seed hardening with $CaCl_2$ @ 2 g/kg	92.67	15.09	13.96	206	2693
T_3-Seed treatment of Pusa hydrogel @ 2.5 kg/ha	96.00	17.09	15.31	233	3111
T_4 -Seed treatment of SPG1118 @ 2.5 kg/ha	97.33	17.43	15.76	248	3230
T_5-Slurry treatment of Pusa hydrogel @ 1:25 ratio	94.33	15.84	14.28	2.11	2842
T_6-Slurry treatment of SPG1118 @ 1:25 ratio	94.67	15.58	14.64	219	2861
T_7-Soil application of Pusa hydrogel @ 5 kg/ha	95.67	16.65	15.00	229	3028
T_8-Soil application of SPG 1118 @ 5 kg/ha	95.33	16.92	15.15	227	3058
S.Em ±	0.31	0.05	0.05	3	12
CD (1%)	1.29	0.22	0.20	12	49

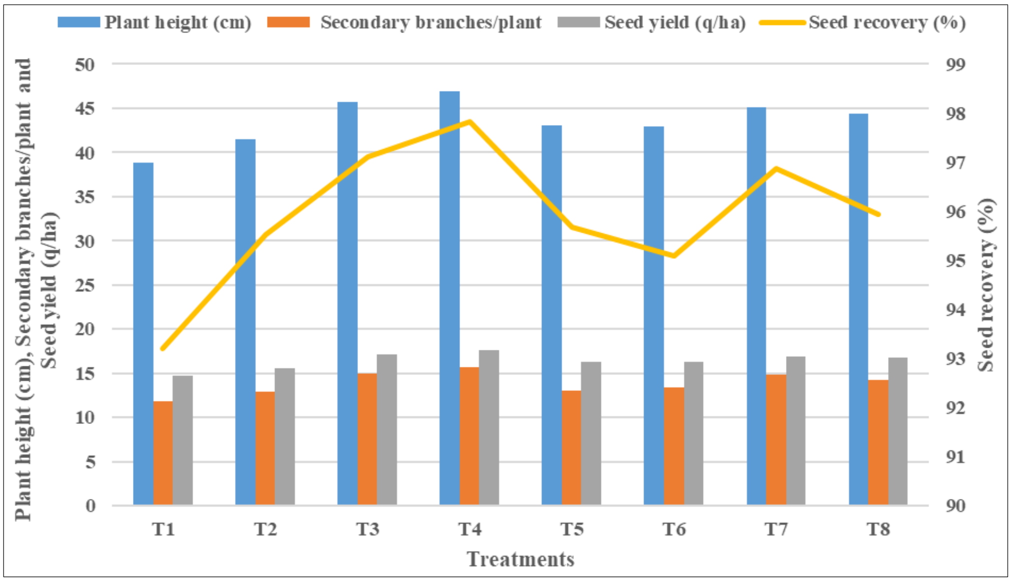

Fig 1: Influence of methods of hydrogel application on plant height (cm), secondary branches/plant, seed yield (q/ha) and seed recovery (%) in chickpea

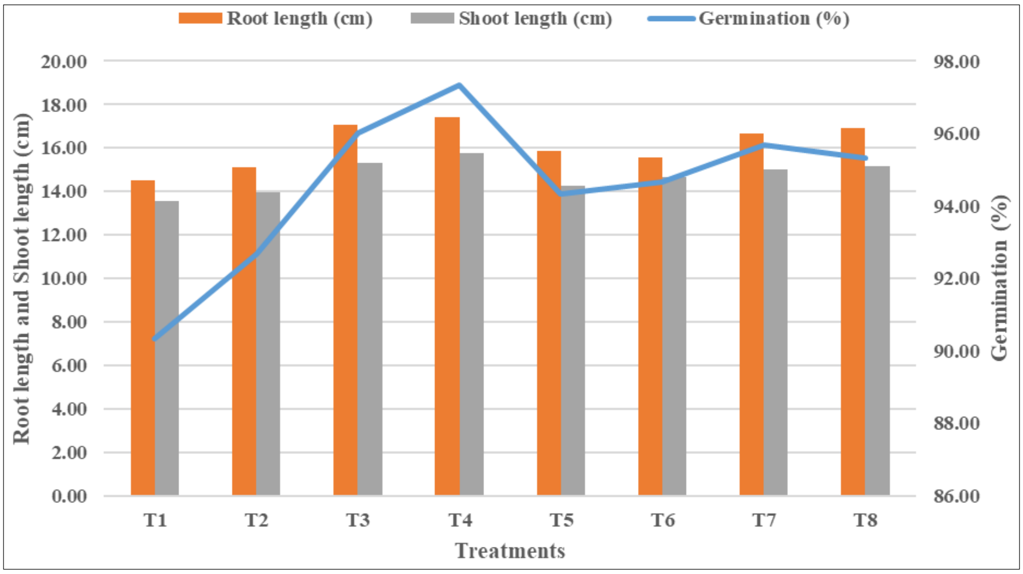

Fig 2: Influence of methods of hydrogel application on seed quality parameters in chickpea

Conclusion

Seed treatment with SPG1118 at 2.5kg/ha found to be more effective over other concentrations. Among the methods of hydrogel application, seed treated with SPG1118 (2.5 kg/ha) recorded significantly higher seed yield and net returns compared with other methods of application. Seed treatment of chickpea with hydrogels found promising in enhancing germination, shoot and root length and productivity of chickpea crop. Thus cost incurred on hydrogels can be reduced and farmers may easily adopt this technology.

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