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PRODUCTIVITY OF CLUSTERBEAN (*Cyamopsis tetragonoloba* L. TAUBERT) AS INFLUENCED BY MOISTURE CONSERVATION PRACTICES AND SEED HARDENING IN SEMI-ARID CONDITIONS

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ABSTRACT

A field experiment was conducted during kharif season of 2022 and 2023 at Jobner (Rajasthan) to assess the Effect of Moisture Conservation Practices and Seed Hardening on yield and yield attributes of Clusterbean (*Cyamopsis tetragonoloba* L.) under rainfed conditions. The experiment was laid out in factorial randomized block design with 3 replications comprising six moisture conservation practices (control, Pusa hydrogel @ 2.5 kg/ha, Pusa hydrogel @ 5.0 kg/ha, stover mulch @ 5.0 t/ha, Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha, Pusa hydrogel @ 5 kg/ha + stover mulch @ 5.0 t/ha) and four seed hardening (control, KH_2PO_4 2%, $KNO_3$100 ppm, $CaCl_2$ 2%). The results revealed that moisture conservation practices significantly influenced the yield attributes and productivity of clusterbean. Application of stover mulch @ 5.0 t/ha markedly improved clusters/plant, pods/plant, pod length, seeds/pod and test weight over the control and Pusa hydrogel alone and produced pooled seed, haulm and biological yields of 1565, 3882 and 5447 kg/ha, respectively, representing about 19% higher seed yield than the control. Although the combined application of Pusa hydrogel and stover mulch recorded numerically higher values, these were statistically comparable with stover mulch alone for several yield parameters, indicating the practical effectiveness of residue mulching under rainfed conditions. Among seed hardening treatments, $CaCl_2$ (2%) proved superior by significantly enhancing yield attributes and recording the highest pooled seed yield (1616 kg/ha), haulm yield (4082 kg/ha) and biological yield (5698 kg/ha). Harvest index remained statistically unaffected by both moisture conservation practices and seed hardening treatments. The improvement in crop productivity under stover mulch was associated with better crop growth, enhanced nodulation, greater dry matter accumulation and improved soil moisture availability, while $CaCl_2$ seed hardening promoted vigorous crop establishment and superior reproductive development. Based on the pooled results of two years, application of stover mulch @ 5.0 t/ha along with seed hardening using $CaCl_2$ (2%) is recommended as an effective and economically viable strategy for enhancing the productivity of rainfed clusterbean in arid and semi-arid regions.

***Keywords*:** Clusterbean, moisture conservation, stover mulch, seed hardening, $CaCl_2$, yield attributes, yield.

Introduction

Clusterbean (*Cyamopsis tetragonoloba* L. Taub.), commonly known as guar, is an important drought-tolerant legume cultivated predominantly under rainfed conditions in the arid and semi-arid regions of India. Besides its importance as a vegetable, fodder and green manure crop, clusterbean is recognized globally as the principal source of guar gum, a galactomannan polysaccharide widely used in the petroleum, food, pharmaceutical, textile and paper industries (Lal *et al.*, 2021). India contributes nearly 80% of the world's guar production and exports, with Rajasthan accounting for the largest share of the cultivated area and production (FAOSTAT, 2023).

Although clusterbean is well adapted to moisture-deficit environments because of its deep root system and drought tolerance, its productivity under rainfed conditions remains low due to erratic rainfall, poor soil moisture availability and frequent dry spells during critical growth stages. Water stress adversely affects seed germination, plant establishment, photosynthesis, flowering, pod development and nutrient uptake, resulting in substantial yield reduction (Farooq *et al.*, 2009). Therefore, developing efficient and sustainable moisture conservation strategies is essential for improving clusterbean productivity in dryland agriculture.

Among the various agronomic interventions, crop residue mulching has emerged as one of the most effective in situ moisture conservation practices. Surface application of crop residues reduces evaporation losses, moderates soil temperature, improves rainfall infiltration, suppresses weed growth and enhances soil organic carbon, thereby improving crop growth and productivity (Lal, 2017). In Rajasthan, mustard stover is readily available after harvest and can be effectively utilized as mulch. Recent studies have reported that residue mulching significantly improves water-use efficiency, yield attributes and seed yield of rainfed crops, making it a practical and economical option for moisture conservation (Choudhary *et al.*, 2025).

Superabsorbent polymers such as Pusa hydrogel have also been explored for enhancing soil water availability under drought conditions. Hydrogels absorb and store large quantities of water and gradually release it according to crop demand, thereby improving soil moisture retention, nutrient availability and crop productivity (Kalhapure *et al.*, 2016). However, because of their comparatively higher cost, crop residue mulching remains a more feasible option for resource-poor farmers in rainfed regions.

In addition to moisture conservation, improving seedling establishment through seed hardening is an effective strategy for mitigating the adverse effects of early-season drought. Seed hardening is a pre-sowing treatment involving controlled hydration followed by drying, which enhances membrane stability, enzyme activity, antioxidant defence and osmotic adjustment, resulting in rapid germination, vigorous seedling growth and improved drought tolerance (Farooq *et al.*, 2006). Among various hardening agents, calcium chloride ($CaCl_2$), potassium nitrate (KNO_3) and potassium dihydrogen phosphate (KH_2PO_4) have shown promising results in improving germination, crop growth and yield under moisture-stress conditions (Jain *et al.*, 2022).

Although the beneficial effects of residue mulching and seed hardening have been reported separately, information regarding their combined influence on yield attributes and productivity of clusterbean under rainfed conditions of Rajasthan is limited. Therefore, the present investigation was undertaken to evaluate the effect of different moisture conservation practices and seed hardening treatments on the yield and yield attributes of clusterbean, with particular emphasis on stover mulch @ 5.0 t/ha as an economical moisture conservation practice and $CaCl_2$ (2%) as an effective seed hardening treatment for enhancing productivity under rainfed conditions.

Materials and Methods

A field experiment was conducted during the *kharif* seasons of 2022 and 2023 at the Agronomy Farm, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University (SKNAU), Jobner, Rajasthan, India (26°05′ N latitude, 75°28′ E longitude and 427 m above mean sea level). The experimental site falls under the Semi-Arid Eastern Plain Zone (Agro-climatic Zone IIIA) of Rajasthan and is characterized by a hot semi-arid climate with low and erratic rainfall, high evaporative demand and sandy soils. The soil of the experimental field was loamy sand in texture, slightly alkaline in reaction (pH 8.1–8.2), low in organic carbon (0.15–0.17%) and available nitrogen, medium in available phosphorus and potassium, and non-saline in nature.

The experiment was laid out in a split-plot design with three replications. Six moisture conservation practices were assigned to the main plots, viz., control (M_0), Pusa hydrogel @ 2.5 kg/ha (M_1), Pusa hydrogel @ 5.0 kg/ha (M_2), stover mulch @ 5.0 t/ha (M_3), Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (M_4) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (M_5). Four seed hardening treatments were allotted to the sub-plots, namely control (S_0), KH_2PO_4 (2%) (S_1), KNO_3 (100 ppm) (S_2) and $CaCl_2$ (2%) (S_3), resulting in 24 treatment combinations.

Clusterbean variety RGC-1033 was used as the test crop. Seeds were sown manually by the *kera* method using a seed rate of 20 kg/ha at a spacing of 30 cm × 10 cm in plots measuring 3.0 m × 4.0 m, with a net plot area of 5.4 m² for recording observations. The field was prepared by deep ploughing followed by cross cultivation and planking to obtain a fine seedbed. The recommended dose of fertilizers was applied uniformly to all plots before sowing. Standard agronomic practices including thinning, interculture, weed management and plant protection measures were followed throughout the crop growth period to raise a healthy crop. A life-saving irrigation was provided only when required during the second year of experimentation.

Seed hardening treatments were imposed by soaking the seeds separately in KH_2PO_4 (2%), KNO_3 (100 ppm) and $CaCl_2$ (2%) solutions using a seed-to-solution ratio of 1:2 (w/v), followed by drying under shade to restore the original seed moisture content before sowing. Pusa hydrogel was mixed with fine dry soil in a 1:10 ratio and applied uniformly in the seed furrows before sowing according to the respective treatments. For mulching treatments, sun-dried mustard stover was spread uniformly between crop rows immediately after sowing at the rate of 5.0 t/ha.

Observations on yield attributes were recorded from five randomly selected and tagged plants in each plot. The number of clusters/plant, pods/plant, pod length and seeds/pod were recorded at maturity, while 1000-seed weight was determined from randomly drawn seed samples after harvest. The crop was harvested from the net plot area at physiological maturity, and biological yield was recorded after sun drying. Following threshing and cleaning, seed yield was determined and expressed as kg/ha, whereas haulm yield was calculated by subtracting seed yield from biological yield. Harvest index was computed as the ratio of seed yield to biological yield and expressed as a percentage.

The experimental data recorded during both years were subjected to analysis of variance (ANOVA) appropriate for the split-plot design following the procedure described by Fisher (1950). The significance of treatment effects was tested using the F-test, and treatment means were compared at the 5% level of significance using the critical difference (CD) test wherever the F-test was significant. Data from both experimental years were pooled after testing the homogeneity of error variances, and pooled results were used for interpretation whenever the year × treatment interaction was non-significant

Results and Discussion

Clusters/plant

Moisture conservation practices and seed hardening significantly influenced clusters/plant during both the years as well as on a pooled basis (Table 1). Among the moisture conservation practices, stover mulch @ 5.0 t/ha recorded significantly higher clusters/plant (9.33) than the control (7.78), Pusa hydrogel @ 2.5 kg/ha (7.91) and Pusa hydrogel @ 5.0 kg/ha (8.60), registering increases of 19.9, 18.0 and 8.5%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (9.61) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (9.66). The higher number of clusters under stover mulch may be attributed to improved soil moisture conservation, reduced evaporative losses and enhanced photosynthetic activity, which favoured better reproductive growth. These findings corroborate those of Jakhar *et al.* (2017), *Gupta et al.* (2020) and Painkra *et al.* (2022).

Among the seed hardening treatments, $CaCl_2$ (2%) recorded the highest clusters/plant (9.42), which was significantly superior to the untreated control (8.21), KH_2PO_4 (2%) (8.78) and KNO_3 (100 ppm) (8.85), showing increases of 14.7, 7.3 and 6.4%, respectively. The beneficial effect of $CaCl_2$ may be attributed to improved membrane stability, enhanced enzyme activity and efficient moisture utilization, leading to better crop establishment and reproductive development. Similar results were reported by Rathod *et al.* (2016), Kunghatkar *et al.* (2018) and Bhadane *et al.* (2021).

Pods/cluster

The number of pods/cluster was significantly affected by moisture conservation practices and seed hardening during both the years as well as on a pooled basis (Table 1). Stover mulch @ 5.0 t/ha produced significantly higher pods/cluster (4.62) than the control (3.29), Pusa hydrogel @ 2.5 kg/ha (3.38) and Pusa hydrogel @ 5.0 kg/ha (3.87), registering increases of 40.4, 36.7 and 19.4%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (4.74) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (4.84). Better moisture availability during flowering and pod initiation under mulch improved flower retention and pod setting, which is in agreement with the findings of Choudhary *et al.* (2017), Jakhar *et al.* (2017) and Gupta *et al.* (2020).

Likewise, $CaCl_2$ (2%) recorded the highest pods/cluster (4.71), which was significantly superior to the untreated control (3.46), KH_2PO_4 (2%) (4.07) and KNO_3 (100 ppm) (4.24), recording increases of 36.1, 15.7 and 11.1%, respectively. Improved pod formation under $CaCl_2$ hardening may be attributed to enhanced metabolic activity, better moisture-use efficiency and greater assimilate translocation towards reproductive sinks, as also reported by Rathod *et al.* (2016), Prabhu *et al*. (2018) and Bhadane *et al.* (2021).

Pods/plant

Moisture conservation practices and seed hardening significantly increased pods/plant during both the years as well as on a pooled basis (Table 1). Stover mulch @ 5.0 t/ha recorded significantly higher pods/plant (43.33) than the control (25.73), Pusa hydrogel @ 2.5 kg/ha (26.84) and Pusa hydrogel @ 5.0 kg/ha (33.46), representing increases of 68.4, 61.4 and 29.5%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (45.74) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (46.93). Improved soil moisture availability under stover mulch promoted photosynthetic efficiency, minimized flower shedding and enhanced assimilate partitioning towards developing pods, thereby increasing pod production. Similar findings were reported by Jakhar *et al.* (2017), Gupta *et al.* (2020), Jorwal *et al*. (2021) and Painkra *et al.* (2022).

Similarly, $CaCl_2$ (2%) recorded the highest pods/plant (44.98), which was significantly superior to the untreated control (28.77), KH_2PO_4 (2%) (36.22) and KNO_3 (100 ppm) (38.05), registering increases of 56.3, 24.2 and 18.2%, respectively. The favourable response to $CaCl_2$ hardening may be attributed to improved seedling vigour, enhanced root growth, better moisture utilization and efficient translocation of photosynthates towards reproductive organs, resulting in greater pod production. These findings are in close conformity with those of Chavan *et al.* (2014), Kunghatkar *et al.* (2018) and Bhadane *et al.* (2021).

Pod length

Moisture conservation practices and seed hardening significantly influenced pod length during both the years as well as on a pooled basis (Table 2). Among the moisture conservation practices, stover mulch @ 5.0 t/ha recorded significantly higher pod length (5.94 cm) than the control (4.40 cm), Pusa hydrogel @ 2.5 kg/ha (4.53 cm) and Pusa hydrogel @ 5.0 kg/ha (5.10 cm), registering increases of 35.0, 31.1 and 16.5%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (6.02 cm) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (6.12 cm). Improved soil moisture availability under stover mulch favoured cell expansion, pod growth and assimilate translocation during the reproductive phase, resulting in longer pods, as also reported by Jakhar *et al.* (2017), Gupta *et al.* (2020) and Painkra *et al.* (2022).

Similarly, $CaCl_2$ (2%) recorded the maximum pod length (6.06 cm), which was significantly superior to the untreated control (4.54 cm), KH_2PO_4 (2%) (5.33 cm) and KNO_3 (100 ppm) (5.46 cm), recording increases of 33.5, 13.7 and 11.0%, respectively. The favourable response to $CaCl_2$ hardening may be attributed to improved membrane stability, enhanced enzyme activity and efficient moisture utilization, leading to better pod development. Similar findings were reported by Rathod *et al.* (2016), Prabhu *et al.* (2018) and Bhadane *et al.* (2021).

Seeds/pod

Moisture conservation practices and seed hardening significantly affected the number of seeds/pod during both the years as well as on a pooled basis (Table 2). Stover mulch @ 5.0 t/ha recorded significantly higher seeds/pod (8.43) than the control (6.77), Pusa hydrogel @ 2.5 kg/ha (7.02) and Pusa hydrogel @ 5.0 kg/ha (7.81), registering increases of 24.5, 20.1 and 7.9%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (8.55) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (8.74). Better moisture conservation under mulch improved fertilization, seed setting and seed filling, resulting in more seeds per pod. Similar observations were reported by Choudhary *et al.* (2017), Jakhar *et al.* (2017) and Gupta *et al.* (2020).

Likewise, $CaCl_2$ (2%) recorded the highest seeds/pod (8.72), which was significantly superior to the untreated control (6.87), KH_2PO_4 (2%) (7.91) and KNO_3 (100 ppm) (8.05), recording increases of 26.9, 10.2 and 8.3%, respectively. Enhanced reproductive efficiency, better nutrient uptake and effective assimilate partitioning under $CaCl_2$ hardening contributed to superior seed development. These findings are in conformity with Jadhav *et al.* (2017), Kunghatkar *et al.* (2018) and Bhadane *et al.* (2021).

Test weight

Moisture conservation practices and seed hardening significantly influenced test weight during both the years as well as on a pooled basis (Table 2). Stover mulch @ 5.0 t/ha recorded significantly higher test weight (28.35 g) than the control (25.32 g), Pusa hydrogel @ 2.5 kg/ha (25.62 g) and Pusa hydrogel @ 5.0 kg/ha (26.99 g), registering increases of 12.0, 10.7 and 5.0%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (28.73 g) and Pusa hydrogel

@ 5.0 kg/ha + stover mulch @ 5.0 t/ha (28.79 g). The improvement in seed weight under stover mulch may be attributed to better soil moisture availability during seed filling, resulting in efficient accumulation of dry matter in seeds. Similar findings were reported by Jakhar *et al.* (2017), Gupta *et al.* (2020) and Jorwal *et al.* (2021).

Similarly, $CaCl_2$ (2%) produced the highest test weight (28.74 g), which was significantly superior to the untreated control (25.25 g), KH_2PO_4 (2%) (27.58 g) and KNO_3 (100 ppm) (27.62 g), registering increases of 13.8, 4.2 and 4.1%, respectively. The superiority of $CaCl_2$ may be attributed to improved physiological efficiency, membrane integrity and enhanced translocation of photosynthates towards developing seeds, resulting in bolder and heavier seeds. These results are in close agreement with the findings of Jadhav *et al*. (2017), Prabhu *et al*. (2018) and Bhadane *et al.* (2021).

Seed yield

Moisture conservation practices and seed hardening significantly influenced seed yield during both the years as well as on a pooled basis (Table 3). Among the moisture conservation practices, stover mulch @ 5.0 t/ha recorded significantly higher seed yield (1565 kg/ha) than the control (1316 kg/ha), Pusa hydrogel @ 2.5 kg/ha (1351 kg/ha) and Pusa hydrogel @ 5.0 kg/ha (1453 kg/ha), registering increases of 18.9, 15.8 and 7.7%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (1606 kg/ha) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (1623 kg/ha). The higher seed yield under stover mulch was mainly attributed to improved soil moisture conservation, enhanced photosynthetic activity and better partitioning of assimilates towards developing seeds, as also reported by Jakhar *et al.* (2017), Ram *et al.* (2018), Gupta *et al.* (2020) and Painkra *et al.* (2022).

Similarly, $CaCl_2$ (2%) recorded the highest seed yield (1597 kg/ha), which was significantly superior to the untreated control (1315 kg/ha), KH_2PO_4 (2%) (1468 kg/ha) and KNO_3 (100 ppm) (1496 kg/ha), registering increases of 21.4, 8.8 and 6.7%, respectively. The favourable response of $CaCl_2$ hardening may be attributed to improved seedling establishment, better moisture-use efficiency and enhanced assimilate translocation towards reproductive sinks. Similar findings were reported by Jadhav *et al.* (2017), Kunghatkar *et al.* (2018) and Syed (2025).

Haulm yield

Moisture conservation practices and seed hardening significantly affected haulm yield during both the years as well as on a pooled basis (Table 3). Stover mulch @ 5.0 t/ha produced significantly higher haulm yield (3882 kg/ha) than the control (3260 kg/ha), Pusa hydrogel @ 2.5 kg/ha (3346 kg/ha) and Pusa hydrogel @ 5.0 kg/ha (3605 kg/ha), recording increases of 19.1, 16.0 and 7.7%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (3988 kg/ha) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (4018 kg/ha). Improved soil moisture availability under mulch enhanced vegetative growth and dry matter accumulation, leading to greater biomass production, as also observed by Jakhar *et al.* (2017), Gupta *et al.* (2020) and Jorwal *et al.* (2021).

Likewise, $CaCl_2$ (2%) recorded the highest haulm yield (3966 kg/ha), which was significantly superior to the untreated control (3286 kg/ha), KH_2PO_4 (2%) (3686 kg/ha) and KNO_3 (100 ppm) (3727 kg/ha), showing increases of 20.7, 7.6 and 6.4%, respectively. Enhanced vegetative growth and biomass accumulation under $CaCl_2$ hardening may be attributed to improved root growth, membrane stability and efficient utilization of available soil moisture. These findings corroborate those of Rathod *et al.* (2016), Kunghatkar *et al.* (2018) and Bhadane *et al.* (2021).

Biological yield

Biological yield was significantly influenced by moisture conservation practices and seed hardening during both the years as well as on a pooled basis (Table 3). Stover mulch @ 5.0 t/ha recorded significantly higher biological yield (5447 kg/ha) than the control (4576 kg/ha), Pusa hydrogel @ 2.5 kg/ha (4697 kg/ha) and Pusa hydrogel @ 5.0 kg/ha (5058 kg/ha), registering increases of 19.0, 16.0 and 7.7%, respectively. However, it remained statistically at par with Pusa hydrogel @ 2.5 kg/ha + stover mulch @ 5.0 t/ha (5594 kg/ha) and Pusa hydrogel @ 5.0 kg/ha + stover mulch @ 5.0 t/ha (5641 kg/ha). The increase in biological yield under stover mulch was associated with sustained crop growth and greater dry matter production due to improved soil moisture conservation, in agreement with Ram *et al.* (2018), Gupta *et al.* (2020) and Painkra *et al.* (2022).

Similarly, $CaCl_2$ (2%) recorded the highest biological yield (5563 kg/ha), which was significantly superior to the untreated control (4601 kg/ha), KH_2PO_4 (2%) (5154 kg/ha) and KNO_3 (100 ppm) (5223 kg/ha), recording increases of 20.9, 7.9 and

6.5%, respectively. Improved physiological efficiency and greater dry matter accumulation under $CaCl_2$ hardening contributed to higher total biomass production. Similar observations were reported by Rathod *et al.* (2016), Kunghatkar *et al.* (2018) and Bhadane *et al.* (2021).

Harvest index

Harvest index was not significantly influenced by either moisture conservation practices or seed hardening during both the years as well as on a pooled basis (Table 3). Although stover mulch @ 5.0 t/ha and $CaCl_2$ (2%) recorded numerically higher harvest index values, the differences among treatments were non-significant, indicating that the increase in seed yield was accompanied by a proportional increase in biological yield.

Conclusion

The present study demonstrated that both moisture conservation practices and seed hardening significantly improved the yield attributes and productivity of clusterbean under rainfed conditions. Among the moisture conservation practices, stover mulch @ 5.0 t/ha proved to be an effective and economical option, significantly enhancing yield attributes, seed yield, haulm yield and biological yield, and was statistically at par with the combined hydrogel treatments. Among the seed hardening treatments, $CaCl_2$ (2%) recorded the highest productivity by improving crop establishment and yield. Therefore, the combined use of stover mulch @ 5.0 t/ha and $CaCl_2$ (2%) seed hardening can be recommended as a sustainable and practical strategy for improving clusterbean productivity semi-arid conditions.

Table 1: Effect of moisture conservation and seed hardening on Clusters/plant, Pods/cluster and Pods/plant of clusterbean

Treatments	Clusters/plant	Pods/cluster	Pods/plant
Moisture conservation			
Control	7.78	3.29	25.73
Pusa hydrogel (2.5 kg/ha)	7.91	3.38	26.84
Pusa hydrogel (5.0 kg/ha)	8.60	3.87	33.46
Stover mulch (5.0 t/ha)	9.33	4.62	43.33
Pusa hydrogel (2.5 kg/ha) + stover mulch (5.0 t/ha)	9.61	4.74	45.74
Pusa hydrogel (5.0 kg/ha) + stover mulch (5.0 t/ha)	9.66	4.84	46.93
SEm±	0.15	0.07	0.71
CD (p=0.05)	0.43	0.21	2.01
Seed Hardening			
Control	8.21	3.46	28.77
KH_2PO_4 (2%)	8.78	4.07	36.22
KNO_3 (100ppm)	8.85	4.24	38.05
$CaCl_2$ (2%)	9.42	4.71	44.98
SEm±	0.12	0.06	0.58
CD (p=0.05)	0.35	0.17	1.64
CV(%)	8.42	8.82	9.47

Table 2: Effect of moisture conservation and seed hardening on seeds/pod, pod length and test weight of clusterbean

Treatments	Seeds/pod	Pod length (cm)	Test weight (g)
Moisture conservation			
Control	6.77	4.40	25.32
Pusa hydrogel (2.5 kg/ha)	7.02	4.53	25.62
Pusa hydrogel (5.0 kg/ha)	7.81	5.10	26.99
Stover mulch (5.0 t/ha)	8.43	5.94	28.35
Pusa hydrogel (2.5 kg/ha) + stover mulch (5.0 t/ha)	8.55	6.02	28.73
Pusa hydrogel (5.0 kg/ha) + stover mulch (5.0 t/ha)	8.74	6.12	28.79
SEm±	0.14	0.08	0.29
CD (p=0.05)	0.39	0.22	0.80
Seed Hardening			
Control	6.87	4.54	25.25
KH_2PO_4 (2%)	7.91	5.33	27.58
KNO_3 (100ppm)	8.05	5.46	27.62

$CaCl_2$ (2%)	8.72	6.06	28.74
SEm±	0.11	0.06	0.23
CD (p=0.05)	0.32	0.18	0.65
CV(%)	8.59	7.13	5.12

Table 3: Effect of moisture conservation and seed hardening on on yield and harvest index of clusterbean

Treatments	Yield (kg/ha)			Harvest index (%)
	Seed	Haulm	Biological	
Moisture conservation				
Control	1316	3257	4572	28.81
Pusa hydrogel (2.5 kg/ha)	1348	3324	4672	28.87
Pusa hydrogel (5.0 kg/ha)	1454	3654	5108	28.49
Stover mulch (5.0 t/ha)	1565	3882	5447	28.73
Pusa hydrogel (2.5 kg/ha) + stover mulch (5.0 t/ha)	1594	3981	5575	28.60
Pusa hydrogel (5.0 kg/ha) + stover mulch (5.0 t/ha)	1616	4026	5642	28.66
SEm±	26	67	79	0.26
CD (p=0.05)	72	189	221	NS
Seed Hardening				
Control	1310	3250	4560	28.76
KH_2PO_4 (2%)	1484	3649	5134	28.92
KNO_3 (100ppm)	1517	3768	5285	28.72
$CaCl_2$ (2%)	1616	4082	5698	28.38
SEm±	21	55	64	0.21
CD (p=0.05)	58	154	180	NS
CV(%)	8	9	7	4.44

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