



Influence of Organic Manure and Hydrogel-based Irrigation Scheduling on Brown Mustard (*Brassica juncea* L.)

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10.18805/ag.D-6280

ABSTRACT

Background: With the increase in population and number of industries in Sikkim, water scarcity is increasing day by day. Thus, water availability for agriculture purpose is a serious concern for the state, whose State's Gross Domestic Product (SGDP) depends up on agriculture. Therefore, a study was formulated with the possibility to mitigate the vulnerability of brown mustard towards water stress.

Methods: The experiment was laid out as pot experiment in the rabi season, 2021-2022 under a CRD setup with 13 treatments replicated thrice. Pot capacity was measured and one seedling was planted per pot. Before planting, hydrogel was applied at recommended doses i.e., 40 g/pot and 20 g/pot.

Result: The investigation concluded that the treatment T₅ (Vermicompost @ 250 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot) was found superior in terms of growth and yield parameters. Vermicompost combined with hydrogel effectively enhanced growth and yield parameters under water stress condition in brown mustard, leading to increased yield. Therefore, treatment T₅ can be further scaled up as a standard practice for brown mustard.

Key words: Brown mustard, CRD, FYM, Hydrogel, Vermicompost.

INTRODUCTION

India is blessed with Himalayan range in the north-eastern region, in this Himalaya lies a pin-point state similar to that of a human thumb, recognized as Sikkim. The state has been working on "Sikkim Organic Mission" and has also been successful in tagging "organic state" to itself with the passage of time on many occasions, nationally and internationally. Agriculture is the main stay of this state, but due to the geographical terrain, the area under cultivation is limited. In Sikkim, brown mustard is the most important leafy vegetable crop. In recent years, *Brassica juncea* L. fetched more attention and focus in global world due to its resistance to salinity and seed shattering. Brown mustard is a suitable crop to grow in a short growing season under the rainfed regions because of the better seed quality in these conditions (Rosengarten, 1969). The crop has wider adaptation and can be grown from the tropical to alpine zone very successfully. Its vernacular name is 'raya saag' an important leafy vegetable for the people in the hilly regions including ethnic populace of Sikkim and other north-eastern states. Brown mustard contains vitamins, dietary fiber, chlorophylls, minerals, glucosinolates and other phytochemicals with antioxidant properties (Park *et al.*, 2017; Ogidi *et al.*, 2019). It can be used to cure several illnesses such as obesity, diabetes, cancer, depression and cataracts. Its extract can also inhibit angiotensin converting enzymes, reduce cholesterol level provides renal is chemoprotection (Tian and Deng 2020).

Over the passage of time, the increasing population and increase in the number of industries in Sikkim, the water scarcity is increasing day by day (Tiwari, 2012). Development of irrigated agriculture is of vital importance

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How to cite this article: Lamichaney, S., Kumar, R., Sharma, L. and Tare, K. (2025). Influence of Organic Manure and Hydrogel-based Irrigation Scheduling on Brown Mustard (*Brassica juncea* L.). Agricultural Science Digest. 1-7. doi: 10.18805/ag.D-6280.

Submitted: 04-01-2025 **Accepted:** 23-06-2025 **Online:** 10-07-2025

in the modern world, where production of food crops needs to keep up with the increasing population. Therefore, more agricultural output can be expected from the effective use of limited water resources (Halagalimath, *et al.*, 2018). The water availability for agriculture purpose is reducing in Sikkim which is a serious concern for the region whose State's Gross Domestic Product (SGDP) depends up on agriculture. In Sikkim, brown mustard is grown in winter season faces severe stress due to lack of irrigation, forcing reliance on streams and tanks.

In India, more than 60% of cultivated area is under dryland condition. The growth of *Brassica* species may be hampered when exposed to a long-term drought stress in areas which are under unassured irrigation scheduling. The development and response of the crop may also be disturbed under such conditions. Suitable irrigation scheduling to the crop can improve its yield and overall quality (Rai *et al.*, 2017). According to some earlier research, in addition to boosting growth and output, timely irrigation

can enhance the nutrient uptake and oil quality of mustard and rapeseed (Singh *et al.*, 2007). It maintains soil health to maintain soil productivity and is a crucial part of an integrated plant nutrient supply system for balanced fertilization (Chaudhary *et al.*, 2004).

Organic manures help to boost soil fertility levels by providing humus and vital nutrients for plants (Babu *et al.*, 2001). FYM helps to raise the cation exchange capacity of the soil and helps to supply different vitamins, hormones and organic acids which are vital for soil aggregation and ultimately helps microorganisms involved in different biochemical processes and nutrient release (Chandra, 2005). Vermicomposting is a way to benefit from some of the services provided by earthworms. In particular, vermicompost reduces the volume of organic waste, stabilize organic matter and increase plant biomass production through several mechanisms: it increases the soil content in organic matter, which in turn decreases the soil bulk density and increases the availability of water and mineral nutrients. Additionally, it has hormone-like effects and lowers the pests and pathogens incidence. It is a renewable source of plant nutrients to supplement the chemical fertilizers (Kumar *et al.*, 2015).

Hydrogel increases nutrient and water use efficiency, improve the physico-chemical characteristics of soil and enhance the crop productivity in semi-arid and arid regions of the world (Mekonnen and Efrem, 2020). Polyacrylamide super absorbent polymer (SAP) is able to retain greater amount of chromium, copper and iron in top soil (Dhiman *et al.*, 2020). Application of hydrogel helps to mitigate the negative impact of deficit irrigation such as lower relative water content, leaf chlorophyll content, electrolyte leakage and membrane stability index in plants (Singh *et al.*, 2019). It is evident from the studies that hydrogel effectively reduce the fruit and vegetable loss caused by pest infestation up to 30% (Bairwa *et al.*, 2020). Seed germination percentage, plant growth and yield is affected by the application of hydrogel in crops like, lettuce, squash, *Brassica oleracea*, barley, white clover, onion and potato (Azzam 1985; Paschold, 1995). It has been also observed that the application of vetterra hydrogel significantly increases the tuber quality and yield of potato (Ezzat *et al.*, 2011). Hydrogel intensifies barrenness by absorbing the water present inside the germinating seed and keeping the water trapped at the surface of the soil. This problem arises when hydrogel is not mixed uniformly into the soil horizon. This polymer improve moisture holding capacity of the soil and supply available water to the plant (Johnson, 1984; Woodhouse, 1989). By considering the facts mentioned above, an experiment was carried out to observe the influence of hydrogel in combination with different organic manure on growth and yield parameters of brown mustard to overcome the water stress. This study is conducted as pot experiment, which may be further scaled up as field application to mitigate the vulnerability of brown mustard towards drought in its growing season.

MATERIALS AND METHODS

The study was formulated at Department of Horticulture, Sikkim University, Gangtok, Sikkim, India and conducted at Badong, Khamdong, Gangtok during the *rabi* season, 2021-2022. Geographically, Khamdong is located at 27.2653°N latitude and 88.483°E longitude. The experiment was laid out as a pot experiment using a Completely Randomized Design (CRD) consisting of 13 treatments replicated thrice viz., T₁; FYM @ 500 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot, T₂; FYM @ 500 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot, T₃; FYM @ 500 g/pot + Irrigation water @ 50% pot capacity + Hydrogel @ 40 g/pot, T₄; FYM @ 500g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot, T₅; Vermicompost @ 250 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot, T₆; Vermicompost @ 250 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot, T₇; Vermicompost @ 250 g/pot + Irrigation water @ 50% pot capacity + Hydrogel @ 40 g/pot, T₈; Vermicompost @ 250 g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot, T₉; FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot, T₁₀; FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot, T₁₁; FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 50% pot capacity + 40 g/pot, T₁₂; FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot, T₁₃ (check); FYM @ 500g/pot + Irrigation water @ 100% pot capacity.

Prior to experimentation, soil was analyzed for various physicochemical characteristics, i.e., pH was examined through digital pH meter (Jackson, 1973); EC (Electrical Conductivity) through digital EC meter (Jackson, 1973); soil organic carbon (%) as per the method suggested by (Walkley and Black, 1934); available nitrogen (Kg/ha) as per the method of Subbiah and Asija, 1956; phosphorous content (Kg/ha) as per the method by (Olsen *et al.*, 1954); potassium content (kg/ha) using flame photometer (Jackson, 1973) and bulk density, particle density and porosity was observed using pycnometer flask. The soil testing was done in triplicates and result revealed that soil pH was 6.8, EC was 0.81 dS/m, organic carbon was 0.8 %, available nitrogen was 325 kg/ha, phosphorous content was 56.45 kg/ha, potassium content was 360 kg/ha and bulk density was observed to be 1.10 g/cm³. Similarly, particle density was calculated as 2.36 g/cm³ and porosity as 53.4%. The pot capacity was determined after drying the soil under sun for three days and water was then added in small amount until the soil reached saturation point and started spilling out of the bottom of pot. This process was repeated thrice and the mean pot capacity (100%) was recorded as 716.66 mL of water. The irrigation scheduling was done on different levels of pot capacity i.e., 100%, 75%, 50% and 25%. A total of four irrigation was given at 15 days interval i.e., 30, 45, 60 and 75 days after transplanting.

The seeds were obtained from local farmers. The pot used for raising the crop was of sufficient dimension [30 cm (W) × 45 cm (H)] to hold the plant efficiently and one plant per pot was planted. It was filled with the soil up to 80% capacity and nutrient media *i.e.*, FYM and vermicompost was applied as per respective treatment. Before planting the seedlings, hydrogel, procured from Vedic Orgo LLP, Nagpur, Maharashtra, India, was applied to the pot at respective doses according to the treatments. The data was recorded from ten plants under each treatment per replication and average value was calculated. All the phenotypic observation were recorded at the time of harvesting using measuring tape and meter scale. The data was analyzed using one way ANOVA by utilizing the OP-STAT online software package. Additionally, a chord diagram was prepared to represent the flow or connections between different treatments and growth and yield attributes of brown mustard.

RESULTS AND DISCUSSION

In present investigation, organic manures alongside hydrogel application significantly affected the growth and yield parameters of brown mustard. For instance, the results revealed (Table 1) that T_5 significantly enhanced plant height (107.33 cm) compared to check treatment (T_{13}). Vermicompost alone improved height more than FYM alone (T_{13}). The soil's water retention might have increased with hydrogel, aligning with (Montesano *et al.*, 2015). Hydrogel positively impacted growth by reducing the moisture stress (Shahid *et al.*, 2012; Akhter *et al.*, 2004). Hydrogels have become a feasible way to enhance crop yields, agribusiness productivity and crop resilience. By highlighting their special qualities, such as their higher water absorption capacity, biodegradability, hydrogels' development and potential revolutionize sustainable agriculture (Ali *et al.*, 2024). Organic manure has been traditionally used in farming to maintain soil fertility and yield. It plays important role in inhabitation beneficial bacteria and make the nutrients available to the crops. Most of the crops absorb nitrogen in the form of nitrate and this form is converted by soil bacteria (Grzyb *et al.*, 2021).

Vermicompost improved soil quality, supporting plant growth as seen by Kansotia *et al.*, 2015. The study found that T_5 significantly enhanced the number of leaves per plant (27.33) over check treatment (T_{13}). T_6 was statistically at par with T_5 and produced slightly lower number of leaves per plant (24), even with reduced irrigation quantity. Vermicompost and hydrogel together boosted leaf count. Using only FYM and irrigation (T_{13}) produced the lowest number of leaves per plant (13). Vermicompost and hydrogel aided nutrient transport and soil processes (Kumar *et al.*, 2018). At harvest, plant girth was significantly affected by T_5 with a value of 12.17cm, followed closely by T_6 with 11.67cm. T_{13} had the lowest girth at 7.43 cm. T_5 and T_6 showed similar effects, highlighting the significance of

vermicompost and hydrogel, even with reduced irrigation. With the capacity to boost crop yields, enhance soil fertility and reduce dependency on synthetic agrochemicals, the use of organic fertilizers, such as vermicompost, farmyard Manure and poultry manure has increased attention (Mishra *et al.*, 2023).

The study found significant changes in plant root length. T_5 had the shortest root length at 11.70 cm, followed closely by T_6 with 12.13 cm. Continuous moisture, facilitated by hydrogel, likely supported robust root growth, this aligns with El-Ashmar *et al.* (2017). Vermicompost's soil enhancement aided nutrient retention and moisture release promoting better root development aligning with Mondal *et al.*, (2008). The study revealed significant effects on the number of primary and secondary roots at harvest. T_5 had the highest count with 16 primary and 48.33 secondary roots, followed closely by T_6 with 14.33 primary and 40.33 secondary roots. T_{13} (Check) had the fewest roots (7.33 primary and 20.67 secondary roots, respectively). The combination of vermicompost and hydrogel likely contributed to this increase. Hydrogel has a special three-dimensional structure that allows them to supply water, nutrients, air, as well as mechanical support, providing the necessary requirement of the root, fostering cell division and organ development, while vermicompost enhances soil nutrients and moisture helps in proper root growth (Mondal *et al.*, 2008 and Ma *et al.*, 2023). Biehl *et al.* (2023), proposed the usage of hydrogel admixture to help in improving soil water storage, with slower water release rates resulting in sustainable plant growth. In the experiment (Table 1), T_5 showed maximum average leaf weight (27.67 gm) and Check, had the minimum average leaf weight (12.67 gm). T_{13} (check) also resulted in the lowest leaf yield per plant (164.33 g), while T_5 had the highest leaf yield per plant (738.33 g). Hydrogel likely aided water retention and vermicompost enhanced soil nutrients and organic matter, aligning with (Singh *et al.*, 2014 and Kansotia *et al.*, 2015). The combined use of vermicompost and hydrogel notably increased brown mustard yield, as supported by Kansotia *et al.* (2015). Using hydrogel and vermicompost together as in T_5 , significantly increased leaf yield, potentially due to better water and nutrient utilization, consistent with El-Asmar *et al.* (2017) and Patel *et al.* (2022). Chord diagram was plotted to determine the weighted relationship among different treatments and growth and yield attributes of brown mustard (Fig 1). In the diagram, it was apparent that T_5 produced maximum numbers of chords or greater arcs related to growth and yield attributes. It was closely followed by T_6 , which also produced greater arcs in the improvement of these traits. The chord diagram justified the importance of different treatments for improvement of different growth and yield related traits through representation of greater arcs in the study. The size of the arc was directly proportional to the improvement in these traits (Patel *et al.*, 2022).

Table 1: Growth and yield parameters of brown mustard.

Treatments	Treatment details	Plant height at harvest (cm)	Number of leaves per plant	Root length (cm)	Leaf length (cm)	Leaf width (cm)	Plant girth (cm)	Number of primary roots	Number of secondary roots	Average leaf weight (g)	Leaf yield per plant (g)
T ₁	FYM @ 500 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot	93.00	20.33	12.53	19.33	14.00	10.07	13.00	35.67	18.33	387.67
T ₂	FYM @ 500 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot	89.33	18.33	13.73	17.33	13.00	9.90	12.67	34.00	16.67	307.33
T ₃	FYM @ 500 g/pot + Irrigation water @ 50% pot capacity + Hydrogel @ 40 g/pot	86.67	18.67	14.57	19.00	11.67	9.43	12.33	34.33	17.00	319.33
T ₄	FYM @ 500g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot	84.00	17.33	17.83	16.33	10.00	8.60	11.00	31.00	15.33	267.67
T ₅	Vermicompost @ 250 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot	107.33	27.33	11.70	28.67	18.33	12.17	16.00	48.33	27.00	38.33
T ₆	Vermicompost @ 250 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot	98.33	24.00	12.13	24.67	15.33	11.67	14.33	40.33	22.67	545.33
T ₇	Vermicompost @ 250 g/pot + Irrigation water @ 50% pot capacity + Hydrogel @ 40 g/pot	95.67	20.33	16.8	19.33	12.67	10.20	12.33	35.67	18.33	376.00
T ₈	Vermicompost @ 250 g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot	78.00	21.00	17.17	21.67	13.67	9.60	12.00	34.33	19.00	399.33
T ₉	FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot	86.33	19.33	19.00	19.00	11.67	9.57	10.00	30.00	17.33	335.00
T ₁₀	FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 75% pot capacity + Hydrogel @ 20 g/pot	86.67	20.33	15.33	20.67	12.00	10.80	11.67	32.67	18.67	380.00
T ₁₁	FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 50% pot capacity + 40 g/pot	78.00	18.33	16.23	19.33	11.67	9.07	11.00	30.67	16.33	299.33
T ₁₂	FYM @ 250 g/pot + Vermicompost @ 125 g/pot + Irrigation water @ 25% pot capacity + Hydrogel @ 40 g/pot	76.67	18.00	18.47	18.67	10.67	9.67	11.67	34.33	16.00	292.67
T ₁₃	Check (FYM @ 500g/pot + Irrigation water @ 100% pot capacity)	68.67	13.00	23.80	13.67	7.67	7.43	7.33	20.67	12.67	164.33
	C.D. (P=0.05)	8.13	3.50	2.19	3.09	2.79	1.74	2.40	7.12	3.44	124.38
	SE (m)	2.78	1.19	0.75	1.05	0.93	0.60	0.82	2.44	1.17	42.55

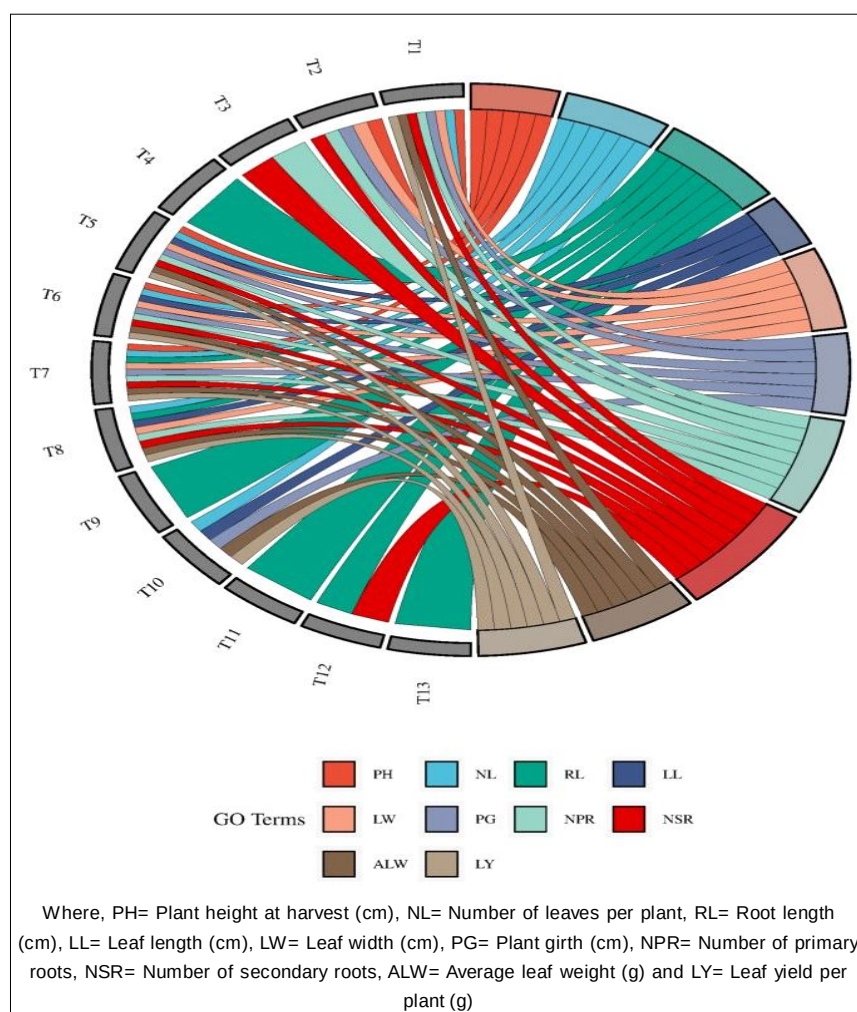


Fig 1: Chord diagram regarding growth and yield parameters of brown mustard.

CONCLUSION

Present study concluded that the treatment T₅ (Vermicompost @ 250 g/pot + Irrigation water @ 100% pot capacity + Hydrogel @ 20 g/pot) was the best treatment among all the treatments, significantly enhanced the growth and yield parameters of brown mustard. The treatment T₅ may be recommended to the farming community to practice as a standard package of commercial cultivation of brown mustard in an organic farming system of beloved Sikkim Himalaya. However, a detailed field trial should be undertaken as a future prospect of the study before the recommendation.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Horticulture, Sikkim University, for providing all-essential facilities for conducting the experiment.

Author's contribution

Rajesh Kumar: Conceptualization and designing of research, Sandhya Lamichaney: Conducted field experiment, recording of data and writing original draft,

Lomash Sharma and Kime Tare: Data analysis and editing of manuscript. No specific grant was received from any funding agencies for conducting the study.

Conflict of interest

The authors declare that there is no competing interest.

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