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RESEARCH COMMUNICATION

Effect of moisture conservation methods on the growth parameters of vegetables grown under rainfed conditions

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Abstract

The study aimed to assess the impact of various moisture conservation practices, combined with soil amendments, on the physicochemical and biological properties of soil, plant growth parameters and crop productivity in a region with an erratic rainfall pattern. A field experiment was conducted at the Advanced Centre for Rainfed Agriculture (ACRA), Dhiansar, Samba district, Jammu and Kashmir, for the years 2022-23 and 2023-24, respectively. This field trial was laid out in a split-plot design comprising twelve treatments with different mulches, replicated thrice. Various moisture conservation methods, including mulch (plastic and organic), along with soil amendments via biochar- 2 t/ha and 4 t/ha, rice husk- 2 t/ha, were compared to RDF (Recommended Dose of Fertiliser with no mulch). Findings revealed that in case of brinjal, T_3 (RDF in combination with 4 t/ha biochar and Plastic Mulch (PM) on application revealed maximum plant height (2022: 84.3 cm, 77.3 cm; 2023: 85.3 cm, 83.0 cm) and fruit weight (2022: 178.6 g, 175.7 g; 2023: 204.7 g, 203.9 g), respectively and in onion, T_3 (RDF in combination with 4 t/ha biochar) and PM recorded maximum plant height (2022: 90 DAT: 53.22 cm, 50.95 cm; 2023: 90 DAT: 54.0 cm, 51.60 cm) and maximum bulb weight (2022: 11485.93 g, 11048.06 g; 2023: 12233.33 g, 11616.67 g), respectively. Whereas, the control group T_1 (RDF) with No Mulch (NM) showed the lower results for both consecutive years 2022-2023. The study highlights the importance of integrating moisture conservation methods in drip irrigation systems to optimise water use and enhance crop growth in rainfed agricultural systems.

Keywords: biochar; brinjal; fruit weight; onion; plant height; rainfed agriculture

Introduction

Rainfall is a major factor in Indian agriculture, with rainfed farming accounting for 45 % of the country's total food grain production. Out of 141 M ha of cultivated land, 92.6 M ha are subjected to rainfed conditions. It makes up to 56 % of India's total agricultural land. Rainfed farming would still occupy almost half of the nation's farmed land even once irrigation potential was fully realised.

Approximately 40 % of the long-term additional foodgrain requirement must be fulfilled by rainfed regions, even under the strongest growth scenarios for irrigated agriculture (1). Drip irrigation plays a remarkable role in rainfed regions, as they experience erratic rainfall patterns and prolonged dry spells. It maintains the optimal soil moisture, encourages the cultivation of high-value crops and also reduces soil erosion, hence maintaining the soil organic matter and its structure.

Biochar is a black carbon produced by pyrolysing biomass, which is a process that produces high-carbon materials by heating biomass slowly without oxygen (2-4). It is also a fine-grained, porous substance that resembles charcoal and is created by burning biomass naturally or under oxygen-limited conditions. Numerous biomass sources, such as wood and bark, agricultural wastes like olive husks, corncobs and tea waste, green waste, animal manures and other waste products, can be used to make it (5). It shows a positive effect in soil by enhancing soil fertility and organic matter, which would ultimately affect the crop growth and development (6). Numerous studies have shown that adding biochar improves crop growth and development, which ultimately leads to better production (7-9).

Often referred to as eggplant, brinjal (*Solanum melongena* L.), a member of the Solanaceae family, is a subtropical and tropical plant that grows every year and is prized for its berry-like fruit. After potatoes, onions and tomatoes, it is the fourth most significant vegetable cultivated in India. It is widely cultivated in China, the Philippines, Bangladesh, Pakistan and India. Since eggplant is a warm-season crop, its life cycle takes 60 to 85 days (10). The states of Andhra Pradesh, Bihar, Karnataka, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal are the primary growing regions for brinjal in India. An estimated 8.14 % of India's vegetable land is used for the growth of brinjal, which accounts for 9 % of the country's total vegetable production. Flavonoids, alkaloids and other bioactive substances, like aspartic acids and arginine, are abundant in this bushy plant.

The fourth most economically significant vegetable crop cultivated globally is the onion (*Allium cepa* L.). India produces 31.68 Mt of onions annually from 1.94 M ha of arable land, making it the world's largest producer. It is a member of the Alliaceae family. The main ingredient that gives onions their pungency is allyl propyl disulfide (11). Since their roots are shallow and unbranched, onions are the least effective crop plants in absorbing nutrients, especially the stationary varieties. 100 g of edible onion bulb has 1.4 g of protein, 11.2 g of carbohydrates, 12 mg of ascorbic acid, 32 mg of calcium and 49 kcal. As a result, they need fertiliser and frequently react favourably to it (12). By preserving ideal soil moisture levels throughout the growing season, a drip irrigation system reduces water stress and avoids excessive moisture retention, improving water productivity when brinjal and onion are grown under rainfed conditions (13). The rainfed area of the Jammu region is categorised by hot summers and dry winters, having low water-holding capacity and low intrinsic fertility. The objective of the study was to evaluate and maximise the favourable effect of various soil amendments along with mulch on growth parameters in the brinjal-onion crop using a drip irrigation system. Our study revealed that soil amendments via biochar, along with mulch, would enhance the growth parameters under rainfed conditions via drip irrigation.

Materials and methods

Experimental site

The experiment was undertaken during 2022 and 2023 at the Advanced Centre for Rainfed Agriculture (ACRA), which is a Dryland Research Station of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu at Dhiansar in Samba District. Geographically, the trial site is located at 32°39' N latitude and 74°58' E longitude with an elevation of 332 m above mean sea level. The topography of the plot was uniform and suitable for brinjal and onion cultivation.

Observation details and methodology

Transplanting was done on each raised bed with a spacing of 90 × 90 cm for brinjal and 10 × 15 cm for onion. The size of each raised bed was 3 x 1 m. In brinjal, the number of plants per replication was 96, whereas in onion, the number of plants per replication was 2088, respectively. Furthermore, five plants were randomly selected from each experimental plot to record the observations. Plant height in brinjal was recorded from the ground tip to the fully opened leaf using a meter scale and the result was expressed in cm. On the other hand, for the onion, the plant height was recorded at different intervals at 30, 60 and 90 Days After Transplanting (DAT). In the case of fruit/bulb weight, individual fruits were picked when fully ripe and further, the weight was taken and recorded in grams. For providing irrigation, a drip irrigation system was installed besides rainfall.

Treatment details

The experiment was carried out in a split-plot design with three main plots and four subplots, allocating different doses of fertilisers and mulches, respectively. Wood ash-derived biochar was used as a soil amendment. Twelve number of treatments were applied i.e. T_1: Biochar (B_0) + NM; T_2: Biochar (B_0) + PM; T_3: Biochar (B_0) + Organic Mulch (OM); T_4: Biochar (B_1) + NM; T_5: Biochar (B_1) + PM; T_6: Biochar (B_1) + OM; T_7: Biochar (B_2) + NM; T_8: Biochar (B_2) + PM; T_9: Biochar (B_2) + OM; T_{10}: Rice Husk (RS) + NM; T_{11}: RS + PM; T_{12}: RS + OM, respectively (Table 1).

Table 1. Treatment details

Main plot	Sub-plot
No mulch	No amendment (RDF: Recommended Dose of Fertilisers)
Plastic mulch	Biochar at 2 t/ha
Organic mulch	Biochar at 4 t/ha
	Rice husk at 2 t/ha

Statistical analysis

The data was analysed using R Studio software and the least significant difference test was used to identify the means at a 5 % significance level.

Results and Discussion

Effect of fertiliser levels on growth parameters of brinjal-onion

Plant height

In Table 2-3, the data revealed that the different fertiliser doses showed a significant effect on the growth parameters of brinjal and onion for both the years 2022 and 2023. The plant height of brinjal was found significantly higher with the application of T_3 [RDF + biochar (4 t/h)], respectively. Plants treated with T_3 showed maximum height [84.3 cm (2022), 85.3 cm (2023)] followed by T_2 [81.4 cm (2022), 80.0 cm (2023)] and the minimum height was recorded in the (T_1) (Fig. 1). In case of onion, plant height was recorded at different intervals (30 DAT, 60 DAT and 90 DAT) respectively. At 30 DAT, non-significant results were observed, whereas 60 DAT and 90 DAT revealed significant results. T_3 showed maximum plant height at 60 DAT [38.94 cm (2022), 39.4 cm (2023)] and 90 DAT [53.22 cm (2022), 54.0 cm (2023)], respectively followed by T_2 and the minimum plant height was recorded in T_1[17.28 cm (2022) and 18.1 cm (2023)], respectively (Fig. 2). A significant variation in the plant height was seen on application of either biochar alone or in combination. In most of the cases, fertilizer application with biochar increased the plant height which might be due to the reason that as biochar helps in improving the soil water retention due to its porous nature which makes the aeration better in the root system which thus, helps in easy uptake of water and nutrients by different biochemical mechanisms and ultimately, reduces the water stress conditions during dry seasons. Additionally, it also affects the soil bacteria in a way that efficiently contributes to the stimulation of plant development by improving plant uptake of nutrients. It may affect soil bacteria in a way that efficiently contributes to the

Table 2. Effect of different mulches, biochar and rice husk on plant height (cm) and fruit weight (g) in brinjal

Brinjal	Plant height (cm)		Fruit weight (g)	
	2022	2023	2022	2023
Main plots				
No mulch	71.7	69.2	139.9	154.2
Plastic mulch	77.3	83.0	175.7	203.9
Organic mulch	75.3	77.6	166.8	197.2
CD (*P≤0.05*)	1.88	2.62	9.25	22.68
Amendments (T)				
T_1: RDF	72.8	74.3	143.2	173.3
T_2: T_1 + B_2	81.4	80.0	162.9	185.7
T_3:T_1+ B_4	84.3	85.3	178.6	204.7
T_4: T_1 + RS	60.7	66.9	158.6	176.8
CD (5 %)	1.27	1.73	16.13	11.12
Interaction	S	S	S	S

Table 3. Effect of different mulches, biochar and rice husk on plant height (cm) at various intervals in onion

Onion	Plant height (cm) (2022)			Plant height (cm) (2023)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Main plots						
No mulch	14.98	32.91	43.93	16.4	33.6	45.0
Plastic mulch	20.03	40.18	50.95	20.9	40.3	51.6
Organic mulch	19.78	38.96	50.44	20.5	39.0	51.3
CD ($P \leq 0.05$)	1.68	1.51	1.54	0.94	1.12	1.07
Amendments (T)						
T_1: RDF	17.28	20.22	45.71	18.1	36.6	46.6
T_2: T_1 + B_2	18.07	36.75	47.46	19.4	37.2	48.9
T_3:T_1 + B_4	20.13	38.94	53.22	20.9	39.4	54.0
T_4: T_1+ RS	17.58	37.23	47.38	18.5	37.4	47.7
CD (5 %)	2.00	1.21	1.34	1.48	1.00	1.31
Interaction	NS	S	S	NS	S	S

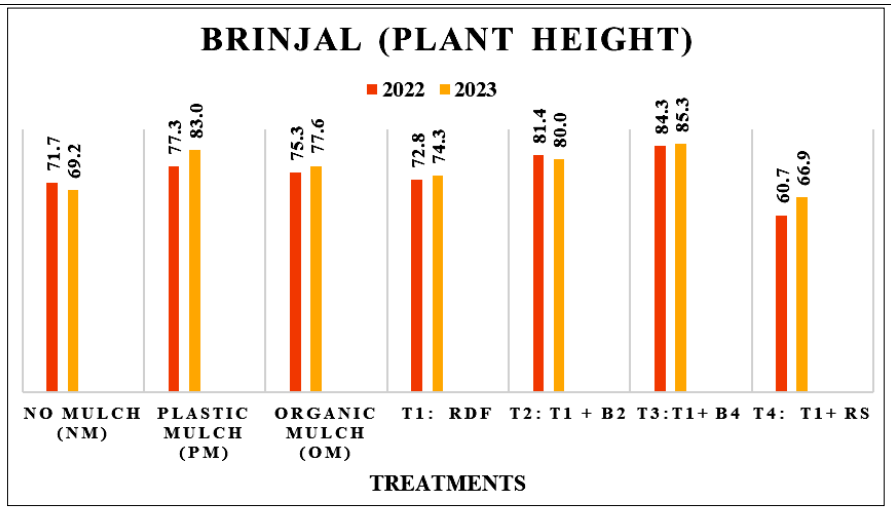

Fig. 1. Effect of mulches and soil amendments on the plant height of brinjal.

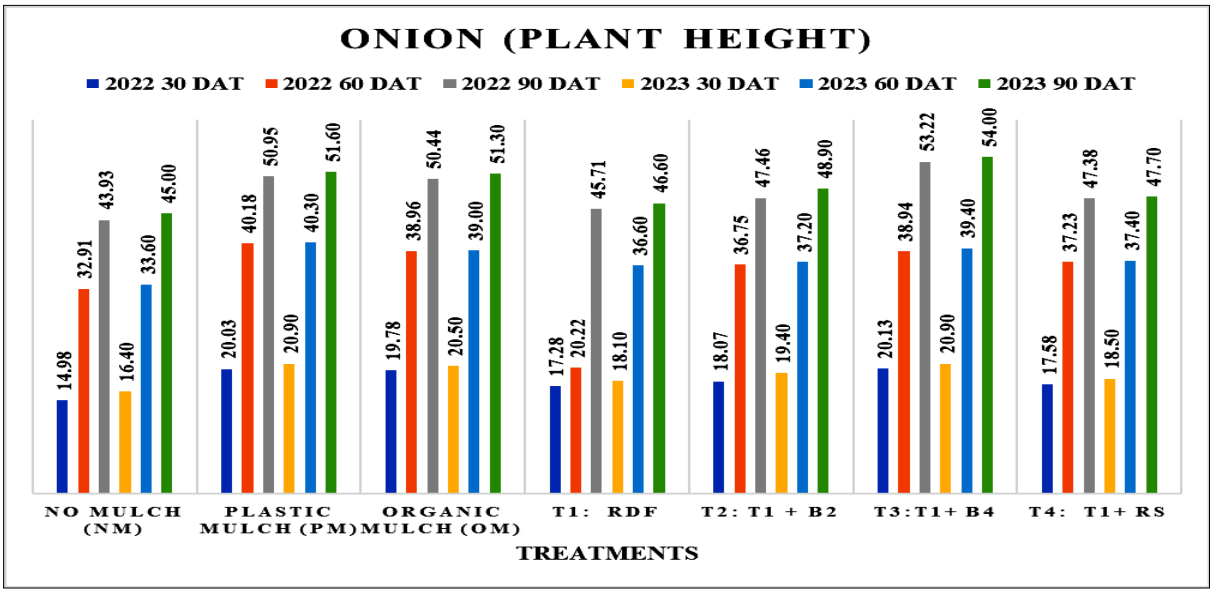

Fig. 2. Effect of mulches and soil amendments on the plant height of onion.

stimulation of plant development by improving plant uptake of nutrients (14). Hence, regular water availability is crucial for enhancing the vegetative growth of the plant (15-16).

Fruit/bulb weight

Data in Table 2 showed significant results for both the consecutive years 2022 and 2023. Hence, in case of brinjal, T_3 recorded the highest values [178.6 g (2022) and 204.7 g (2023)], followed by T_2 [162.9 g (2022) and 185.7 g (2023)], T_4 [158.6 g (2022) and 176.8 g (2023)] and T_1 [143.2 g (2022) and 173.2 g (2023)] (Fig. 3). Whereas, in case of onion, T_3 recorded the highest values for bulb weight, [11485.93 g (2022) and 12233.33 g (2023)], followed by T_2 [10442.22 g (2022) and 10925.93 g (2023)], T_4[9415.10 g (2022) and 9518.52 g (2023)] and T_1 [8728.15 g (2022) and 9425.93 g (2023)] (Fig. 4, Table 4). Soil amendments showed the best results which might be due to the reason that incorporation of biochar into the soil, enhances the availability of soil cations and phosphorus, total nitrogen and soil cation exchange capacity which ultimately leads to an increase in overall fruit/bulb weight as it has the potential to mitigate nutrient leaching, particularly potassium and nitrogen in the form of ammonium ion. Further, it improves soil water retention capacity and nutrient availability, promoting plant growth and fruit quality. Our findings are in accordance with previous studies (17,18).

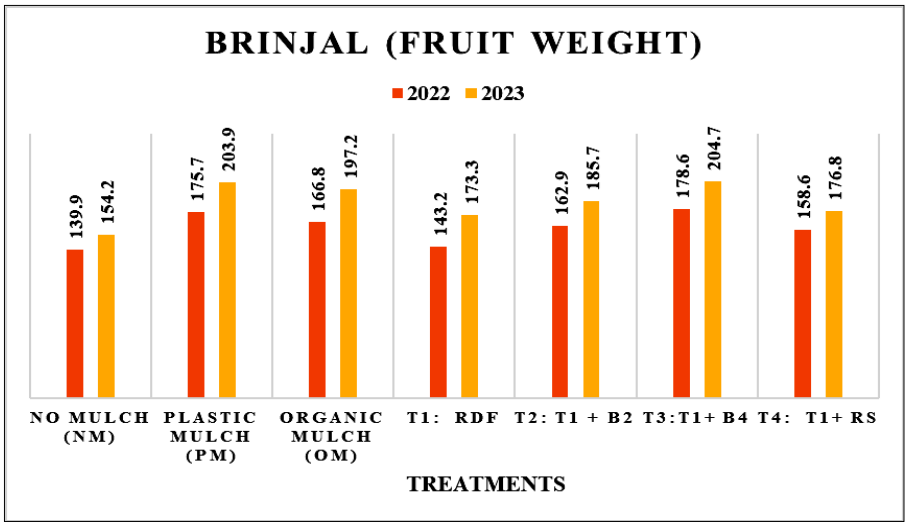

Fig. 3. Effect of mulches and soil amendments on the fruit weight of brinjal.

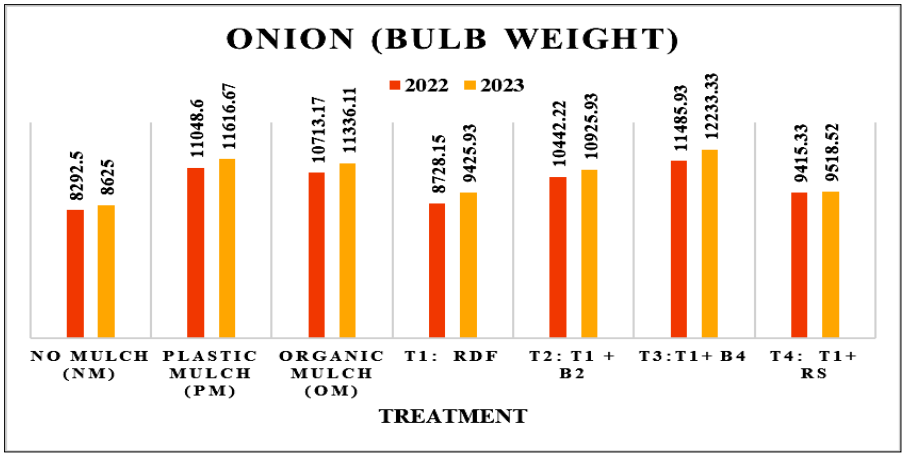

Fig. 4. Effect of mulches and soil amendments on the bulb weight of onion.

Table 4. Effect of different mulches, biochar and rice husk on bulb weight (g/plot) in onion

Main plots	Bulb weight (g)	
	2022	2023
No mulch	8292.50	8625.00
Plastic mulch	11048.06	11616.67
Organic mulch	10713.17	11336.11
CD (*P ≤0.05*)	394.82	265.70
Amendments (T)		
T_1: RDF	8728.15	9425.93
T_2: T_1 + B_2	10442.22	10925.93
T_3:T_1 + B_4	11485.93	12233.33
T_4: T_1 + RS	9415.33	9518.52
CD (5 %)	497.10	206.11
Interaction	S	S

Effect of various mulches on growth parameters of brinjal-onion

Plant height

The presented data revealed that significantly higher results were observed in plants treated with plastic mulch as compared to the other treatments. In the case of brinjal, maximum plant height as well as fruit weight was observed in plants treated with PM. PM revealed higher plant height [77.3 cm (2022) and 83.0 cm (2023)], respectively, whereas greater fruit weight [175.7 cm (2022) and 203.9 cm (2023)] was also recorded in the same. In the case of onion, significantly higher plant height [50.95 cm (2022) and 51.6 cm (2023)] 90 DAT was recorded under PM (Table 2). Higher bulb weight was also revealed under PM, i.e. [11048.06 g (2022) and 11616.67 g/plot (2023)]. This might be due to the availability of optimum soil moisture and temperature that promotes vegetative growth, yielding the maximum plant height (19). Also, soil amended with biochar at higher rates can balance the stress caused by drought, mainly through increasing soil organic matter content, improving nutrient uptake, maintaining soil moisture and improving soil physical properties, including reduced bulk density that eventually increases the plant height (20). Weed suppression along with optimum moisture availability and, ideal microenvironment significantly affected the overall bulb production (21).

Fruit/bulb weight

Data in Table 2 reveal significant differences in fruit/bulb weight among the mulching treatments for both the consecutive years 2022 and 2023. In the case of brinjal, PM recorded the highest fruit weight with 175.7 g (2022) and 203.9 g (2023), followed by OM [166.8 g (2022) and 197.2 g (2023)], while NM had the lowest fruit weight [139.9 g (2022) and 154.2 g (2023)]. Moreover, in case of onion, bulb weight was recorded highest under PM with 11048.06 g (2022) and 11616.67 g in (2023), followed by OM [10713.17 g (2022) and 11336.11 g (2023)], while NM had the lowest bulb weight [8292.5 g (2022) and 8625.0 g (2023)]. The Critical Difference (CD) values at 5 % significance level indicated that these differences were statistically significant for both parameters across the two years. Fruit parameters were improved in plastic mulch, as it significantly improves the moisture conservation and availability in soil (22). Therefore, better moisture conservation, besides reduced evaporation rates, weed control, good moisture conservation and ideal micro-environment, facilitated by mulches, shows a profound impact on fruit weight/bulb production as it reduces competition for nutrients, space and light (23-25).

Conclusion

Different mulches, biochar and rice husk on a combined application showed significant results; it should be judiciously and accurately applied in the field for acquiring improved results. Thus, it can be concluded that the application of T_3 (RDF + 4 t biochar/ha) along with plastic mulch observed enhanced plant height and fruit or bulb weight in the brinjal-onion sequence.

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Authors' contributions

DV contributed to conceptualisation, writing the original draft, writing and revising the manuscript and visualisation. VA contributed to the conceptualisation and editing of the manuscript. PS contributed to writing the original draft of the manuscript. AC contributed to writing the original draft, writing and revising the manuscript, visualisation and editing. HS contributed to the visualisation. AKS contributed to the visualisation. SK contributed to the editing of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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