*Indian Journal of Agricultural Sciences* **94** (1): 096–099, January 2024/Short Communication
https://doi.org/10.56093/ijas.v94i1.142855

# Land configurations and drought mitigation practices to improve productivity and profitability of blackgram (*Vigna mungo*) under moisture stress conditions

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Received: 23 September 2023; Accepted: 15 November 2023

**Keywords**: Blackgram yield, Broad bed and furrow, KCl, Mulching, PPFM, Pusa hydrogel

Blackgram [*Vigna mungo* (L.) Hepper] mostly grown under rainfed condition faces a problem of excess soil moisture and water logging during early season and moisture deficit at reproductive phases resulting low productivity. Under such condition appropriate land configuration technologies play an important role in increasing production. Broad Bed and Furrow (BBF) method helps maximize infiltration thereby increase moisture storage in soil profile and root proliferation. It also minimizes bulk density, erosion and runoff, helps to drain excess water during heavy rainy season and increase water use efficiency, growth and yield of crop (Haqmal *et al*. 2023).

Soil moisture affects the uptake and availability of plants nutrients, improves soil condition and influence many physiological activities in the plant. Hence, ample amount of soil moisture availability is essential for better crop growth and yield (Dass and Bhattacharyya 2017). Application of super absorbent is a useful technology to sustain yield under drought. Polymer treated plots registered higher crop yields than no polymer applied plots (Nazarli and Zardashti 2010, Rajanna *et al*. 2022). Mulching protects soil from drying and hard-baking effects, lower the soil temperature during day time than non-mulched plot (Dass and Bhattacharyya 2017). Earlier studies have proved that, covering soil with crop residue make possibility of second crop with residual soil moisture in rainfed situation where only a single crop is grown in a year (CRIDA 2011–12).

Potassium plays an important role under rainfed, moisture stressed conditions. Foliar application of 1% KCl + 1% $KNO_3$ increased green gram yield by 21.8% over control (Govindan and Thirumurugan 2000). Mohammand *et al*. (2011) reported plots which received potassium as $K_2SO_4$ (250 kg/ha) increased sorghum grain number/ panicle by 50% over control. Application of 1012 CFU/ml of *Methylobacterium* spp. or 20% methanol as foliar spray significantly increased growth and yield attributes and yield of peanut over control (Alireza Hosseinzadeh Gashti *et al*. 2014). Developing comprehensive drought mitigation techniques could conserve soil moisture and enhance productivity of blackgram. Hence, the present study was carried out to know the effect of different drought mitigation technologies on growth and yield of blackgram.

Present study was carried out during winter (*rabi*) season of 2018–19 at Agricultural Research station, Kovilpatti, Tamil Nadu to assess the effect of drought mitigation technology on plant water status, crop yield and economics of blackgram under dryland condition. The experiment conducted in strip-plot design with 3 replications. Vertical factors including FB and BBF and horizontal factors, viz. Pusa hydrogel (5.0 kg/ha), mulching with crop residue (5.0 t/ha), PPFM 1% spray, KCl 1% spray and KCl 1% + PPFM 1% spray at 30 and 45 days after sowing (DAS), Pusa hydrogel (5.0 kg/ha) + mulching with crop residue (5.0 t/ha), Pusa hydrogel (5.0 kg/ha) + mulching with crop residue (5.0 t/ha) + KCl 1% spray at 30 and 45 DAS, Pusa hydrogel (5.0 kg/ha) + mulching with crop residue (5.0 t/ha) + PPFM 1% spray at 30 and 45 DAS were tried.

As per the package of practices, all the cultural practices were followed. Sorghum, maize and minor millets straw were used as a mulching material. Pusa hydrogel (gel-forming polymers) was used to improve the water-holding properties. Pink-Pigmented Facultative Methylotrophs (PPFM) formulated by Tamil Nadu Agricultural University (TNAU) was used for this experiment. Relative water content (RWC%), Chlorophyll stability index (CSI%), soil moisture and leaf proline content were estimated as per the procedure of Pieczynski *et al*. (2013), Agarie *et al*. (1995), Gravimetric method and Bates *et al*. (1973) method respectively. Data on growth, yield attributes and yield were recorded plot-wise from each replication and statistically analyzed following procedures as described by Gomez and Gomez (2010).

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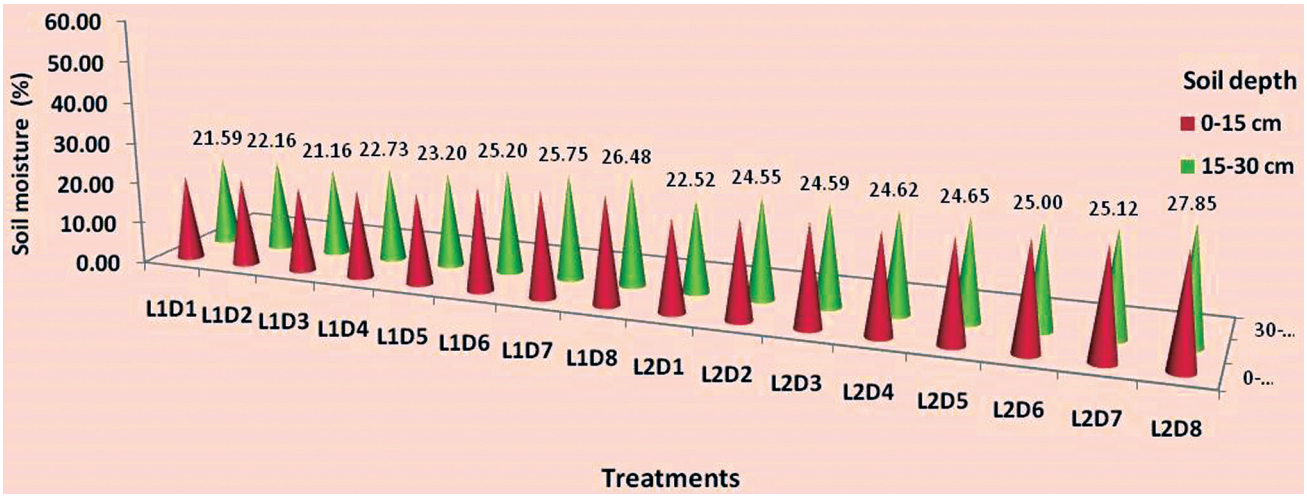


Fig. 1 Effect of land configuration and drought mitigation methods on soil moisture (%) at vegetative stage of blackgram.

*Soil moisture and plant water status*: Available soil moisture was high in the formation of BBF with combined application of Pusa hydrogel + mulching + PPFM spray @27.8% on 30$^{th}$ DAS during 2018–19 (Fig. 1). Vekariya *et al.* (2015) observed that, higher soil moisture content under BBF system than FB method. Wani *et al.* (2011) found that mulching reduced soil evaporation and increased WUE of crops. Hydrophilic nature of hydrogel allows it to absorb 200–400 times its weight of water. Hence, application of hydrogel in rhizosphere helps to overcome dry spells by retaining soil moisture for a longer time period (Kalhapure *et al*. 2016).

RWC (92.8%) and CSI (87.6%) were significantly influenced by land configuration techniques and these were higher in BBF (Table 1). While, treatment recorded lower proline value of 35.5 µg/g due to furrows act as a conservator of rainwater helps in maintaining higher soil moisture in soil as well in plant thus results in better performance of crop during dry spells (Srinivasa Rao and Gopinath 2016). Mohammed Ashraf *et al.* (2020) found that combined effect of formation of BBF + soil application of Pusa hydrogel + PPFM spray resulted higher RLWC, seed cotton yield and lower values of proline content due to sufficient availability of water in cell.

Among the drought mitigation methods, higher RWC (92.8 %) and CSI (87.6%) and lower proline content (34.5 µg/g) were recorded in the combined application of Pusa hydrogel + mulching + PPFM spray due to the higher moisture availability. Mulching reduces evaporation, protects the soil from direct effect of sunlight and wind and reduces the soil temperature, thereby reduces water loss (Srinivasarao and Gopinath 2016) in turn increases plant water status. PPFM produces osmoprotectants which help the plants from desiccation and high temperature resulted increased plant RWC, CSI content. Sivakumar *et al*. (2017) observed that PPFM (2%) spray increased SPAD value, RWC, photosynthetic rate and decreased proline content which has the ability to protect the plant under abiotic stress by nullifying oxidative damage.

*Dry matter production (DMP)*: DMP was significantly higher in land configuration of BBF method, which was 17.6 % higher than FB (Table 1). Among the drought mitigation methods, significantly higher DMP of 2613 kg/ha was recorded in the combined application of Pusa hydrogel + mulching + PPFM spray which was 42% higher than hydrogel applied plot. Nazarli and Zardashti (2010) reported 300 kg/ha higher seed yield in polymer treated plot and the lowest value was recorded in no polymer treated plot receiving irrigation after 14 days. Straw mulch and evaporation retardants help to conserve more soil moisture in the soil profile up to 180 cm deep which in turn helps to increase the growth of plant (Aujla and Cheema 1983). Inoculation of PPFM along with methanol significantly increased plant dry matter by producing plant growth regulator like zeating and cytokinin, plant hormones and vitamins (Sundaram *et al*. 2002).

*Effect of treatment on grain yield*: Grain yield was significantly higher in the land configuration of BBF method which recorded 459 kg/ha (Table 1). The increased yield was to an extent of 18% over FB method. This might be due to better improvement in moisture content at different growth stages of the crop.

Significantly higher yield of 480 kg/ha was registered in the combined application of Pusa hydrogel + mulching + PPFM spray which was 23% higher than hydrogel alone applied plot (391 kg/ha). Yield attributes and yield increase by above methods was also reported by Sivakumar *et al*. (2017) and Rajesh Kumar *et al*. (2018).

*Rainfall-use efficiency (RUE) and economics*: RUE was higher in the land configuration of BBF method which recorded RUE of 3.81 kg/ha-mm which is 41% higher than FB. Similarly, higher gross return, net return and B: C ratio was recorded by the BBF method due to increased yield under this treatment (Table 1).

Among the drought mitigation methods, higher RUE of 3.33 kg/ha-mm was recorded by the combined application of Pusa hydrogel + mulching + PPFM spray due to increased

Table 1 Effect of land configurations and drought mitigation technologies on proline, RWC, CSI, DMP and yield of blackgram

| Treatment | Proline (µg/g) | RWC (%) | CSI (%) | DMP (kg/ha) | Grain yield (kg/ha) | RUE (kg/ha-mm) | Cost of cultivation (₹/ha) | Gross return (₹/ha) | Net return (₹/ha) | B : C ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| *Land configuration (Vertical factor)* | | | | | | | | | | |
| $L_1$, Flat bed | 35.5 | 84.6 | 81.5 | 2079 | 390 | 2.71 | 20,123 | 18,732 | -1,391 | 0.94 |
| $L_2$, Broad bed and furrow | 37.9 | 90.1 | 85.7 | 2446 | 459 | 3.81 | 19,023 | 22,020 | 2,998 | 1.17 |
| SEd | 0.9 | 1.5 | 1.2 | 113 | 21 | - | - | - | - | - |
| CD (P=0.05) | 2.0 | 3.1 | 2.2 | 260 | 49 | - | - | - | - | - |
| *Drought mitigation methods* (*Horizontal factor)* | | | | | | | | | | |
| $D_1$, Pusa hydrogel (5.0 kg/ha) | 40.0 | 84.6 | 80.6 | 1841 | 391 | 2.71 | 20,460 | 38,160 | -1,692 | 0.92 |
| $D_2$, Mulching with coir pith (5 t/ha) | 36.6 | 90.1 | 84.2 | 2119 | 413 | 2.86 | 16,660 | 40,080 | 3,140 | 1.19 |
| $D_3$, PPFM 1% spray at 30 and 45 DAS | 38.1 | 89.3 | 84.0 | 2172 | 395 | 2.74 | 17,360 | 39,600 | 1,600 | 1.1 |
| $D_4$, KCl 1% spray at 30 and 45 DAS | 38.1 | 89.1 | 83.5 | 2187 | 393 | 2.72 | 16,660 | 39,360 | 2,180 | 1.14 |
| $D_5$, $D_3$+$D_4$ | 37.8 | 90.2 | 86.1 | 2295 | 428 | 2.97 | 17,360 | 41,040 | 3,160 | 1.19 |
| $D_6$, $D_1$+$D_2$ | 36.1 | 90.5 | 86.8 | 2404 | 440 | 3.05 | 21,660 | 42,240 | -540 | 0.98 |
| $D_7$, $D_1$+$D_2$+$D_4$ | 35.7 | 92.3 | 87.9 | 2467 | 458 | 3.17 | 22,860 | 43,200 | -900 | 0.96 |
| $D_8$, $D_1$+$D_2$+$D_3$ | 34.5 | 93.5 | 88.7 | 2613 | 480 | 3.33 | 23,560 | 44,160 | -520 | 0.98 |
| S Ed | 1.1 | 0.90 | 1.1 | 136 | 23 | - | - | - | - | - |
| CD (0.05) | 2.2 | 1.8 | 2.4 | 285 | 49 | - | - | - | - | - |

RWC, Relative water content; CSI, Chlorophyll stability index; DMP, Dry matter production; RUE, Rainfall use efficiency; B:C ratio, Benefit cost ratio.

yield than other treatments. The higher gross return of ₹23040/ha was recorded by the combined application of Pusa hydrogel + mulching + PPFM spray. However, the higher additional costs for purchase of pusa hydrogel need to be considered before using these practices under rainfed condition. Higher net return of ₹3,160/ha was recorded by the combined application of PPFM 1% spray and KCl 1% spray. Whereas higher B: C ratio of 1.19 was registered by the mulching with coir pith (5 t/ha) which was followed by combined application of KCl 1% + PPFM 1% spray at 30 and 45 DAS and KCl 1% spray at 30 and 45 DAS due to lower cost of cultivation.

From the field study it could be concluded that, formation of BBF along with combined application of pusa hydrogel (5.0 kg/ha) with crop residue mulching (5 t/ha) and PPFM 1% spray at 30 and 45 DAS recorded higher growth and yield attributes and yield of crops and higher RUE under moisture stress condition. Higher net return and B:C ratio was recorded by BBF method with combined application of KCl 1% + PPFM 1% spray at 30 and 45 DAS and mulching with coir pith (5 t/ha) due to low cost of cultivation.

If sufficient quantity of crop residue is available with farmers, farmers can go for mulching the field otherwise farmers can choose spraying of KCl 1% + PPFM 1% for higher economic benefit under dryland vertisols condition.

Due to non-availability of FYM, application of crop residue will play major role in adding plant nutrients and soil moisture conservation. Due to climate change, vagaries of weather is prevalent in Indian agriculture. Hence study on effect crop residue and KCl and PPFM spray on different crops will gain importance.

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