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Influence of induced moisture stress at critical crop growth stages on yield, yield attributes and economics of rabi maize

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Abstract
Moisture stress one of the most severe environmental stresses causing significant damage to agricultural crop production. It inhibits growth and development in plants. Maize plants are sensitive to moisture stress. In this regard, an experiment was laid out in randomized complete block design with three replications and nine treatments (Irrigations scheduled at different growth stages and varying the stage and number of irrigations) during *rabi* (2021-22) at University of Agricultural Sciences, Dharwad to study the influence of induced moisture stress on yield, yield attributes and economics of *rabi* maize. Results revealed that grain rows cob^{-1} (15.2), number of grains row^{-1} (33.6), number of grains cob^{-1} (509.6), cob weight (174.8 g), grain weight cob^{-1} (130.1g), shelling percentage (74.5%) and test weight (34.6 g) recorded with irrigations at all growth stages and at par with skipping irrigation only at milky stage. Significantly higher kernel yield (7040.7 kg ha^{-1}), gross monetary returns (₹1,44,514 ha^{-1}), net monetary returns (₹ 99,052 ha^{-1}) and benefit- cost ratio (3.18) were obtained with irrigations at all stages. Higher kernel yield reduction (62.7%) was recorded with irrigations upto knee high stage followed by skipping irrigation at all critical stages recorded the next highest kernel yield reduction (61.2%). Among combination of growth stages, skipping of irrigation at both tasseling and silking higher yield reduction (47.7%) over other combination of skipping growth stages.

Keywords: Moisture stress, kernel yield, gross monetary returns, net monetary returns, benefit cost ratio

1. Introduction

Maize (*Zea mays* L.) is one of the important cereal crops used as a multipurpose crop with wide adaptability to different agro-climatic conditions. In India, maize is grown in an area of 10.74 M ha with a production of 35.67 MT and productivity of 3321 kg ha^{-1} [1]. It is grown in most parts of the world and most preferred crop by the farmers because of its highest productivity and dual purpose use i.e. grain and fodder. Globally, maize is an industrial crop rather than a food crop because, of the total maize produced only 12 - 13% is used for human consumption whereas in India around 50% of maize is used for poultry feed, 12% for animal feed and 25% is used for consumption [2].

In India, maize crop requires at least 600 mm of rainfall for better yields. The rainfall mostly occurs in the early growth stages, and the crop faces moisture stress from the pre-flowering to late grain-filling stages. It considerably affects the pollination, seed setting and seed quality. Hence, maize production in the wet season and in rain-fed regions is in declining trend. However, dry-season maize areas are currently expanding in India due to higher productivity than in rainfed and wet areas. *Rabi* maize requires 600 - 900 mm of water for optimum yields based on the duration of variety. Moisture stress one of the most severe environmental stresses causing significant damage to plants [3, 4]. It inhibits growth and development in plants [5, 6]. Moisture stress at critical crop growth stages leads to drastic yield reduction. Critical crop growth stages in maize are seedling stage, knee high stage, flowering (tasseling and silking) and grain filling stage. Yield loss in maize can vary from 30 to 90% depending on the duration, stage and intensity of moisture stress [7]. In fact, water stress during the silking and grain filling stages may cause yield losses of 50 and 21%, respectively [8].

Yield attributes such as cob length, cob width, number of rows per cob, number of kernels per row, number of kernels per cob, thousand kernel weights and kernel yield ha^{-1} were badly influenced by the water stress at pre-anthesis and during-anthesis stages [9]. Moisture stress during anthesis reduces the volume of the embryo and delay the time of grain filling due to premature endosperm desiccation. In addition, moisture stress shortens the effective grain-filling period, which lowers grain yield. Kernel number per cob significantly purloined with increasing duration of moisture stress at crop root zone [10]. In maize, lower kernel number per cob was found under water-stress conditions, as compared to those grown in water-sufficient conditions. Moisture stress during grain filling stage doesn't affect the number of grains per cob unless severe moisture stress is imposed at the beginning of grain filling stage [11]. If both the tasseling and silking stages were subjected to moisture stress, 32-50% reductions in the kernel number were obtained [12]. So irrigation management during should be accurate to overcome the yield loss.

2. Materials and Methods

The experiment was conducted during *rabi* season of 2021-22 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The geographical coordinates of experimental site is 15º 29' North latitude and 74º 59' East longitude at an altitude of 678 m above mean sea level. The soil of the experimental site was medium deep black soil *(Vertic Inceptisol)* with clay texture, slightly alkaline (pH 7.80), with normal electrical conductivity (0.32 dS m^{-1}), low in organic carbon content (0.46%), low in available nitrogen (278.00 kg N ha^{-1}), medium in available phosphorus (35.00 kg P_2O_5 ha^{-1}) and high in potassium (393.00 kg K_2O ha^{-1}). Field capacity of the experimental site at 0-15 cm depth is 30.52% and permanent wilting point at the same depth is 18.02%.

Maize hybrid NK-6240 with spacing of 60 × 20 cm was used for the investigation. During the crop growing period (10th December 2021 - 8th April 2022) a total rainfall of 57.2 mm was received in the last two weeks of March (48.8 mm) and first two weeks of April (8.4 mm). There was no influence of rains over skipping of irrigation at critical stages and no deviation in treatment imposition. Fertilizers were applied at the rate of 150: 65: 65 N: P_2O_5: K_2O kg ha^{-1} in the form of urea (N), Di-Ammonium phosphate (DAP) and Muriate of potash (K_2O). At the time of sowing, 50% of N and 100% of P_2O_5 and K_2O were applied as basal dose followed by 50% of N applied at 35 days after sowing. Irrigation was provided after sowing (VE) to ensure uniform germination and establishment of the crop. Later irrigation was scheduled at four leaf stage (V4) and knee high stage (V8), for all the treatments. Subsequent irrigations were scheduled as per the treatments at tasseling stage (VT), silking stage (R1), milky stage (R3) and dough stage (R4). The experiment was laid out in randomized complete block design with nine treatments and three replications. Treatment comprises T_1: Irrigations at all growth stages (VE, V4, V8, VT, R1, R3 and R4), T_2: Skipping irrigation only at tasseling (VT), T_3: Skipping irrigation only at silking (R1), T_4: Skipping irrigation only at milky stage (R3), T_5: Skipping irrigation at tasseling and silking (VT and R1), T_6: Skipping irrigation at tasseling and milky stage (VT and R3), T_7: Skipping irrigation at silking and milky stage (R1 and R3), T_8: Skipping irrigations at all critical stages (tasseling, silking and milky stage) and T_9: Irrigations upto knee high stage (V8). Irrigation was provided to each plot with 2 inches pipe (siphon) at a discharge rate of 2.5 liters sec^{-1}. Care was taken to minimize horizontal movement of water to other treatments. The data on no. of grain rows cob^{-1}, no. of grains row^{-1}, no. of grains cob^{-1}, test weight, cob weight, grain weight cob^{-1}, shelling percentage, kernel yield ha^{-1} and stover yield is collected on the day of harvest. Cost of cultivation, gross income, net income and benefit cost ratio of the current study is worked out and presented. The data collected from the experiment was subjected to statistical analysis as described by [13]. The level of significance used in 'F' and 't' test was P= 0.05. Critical difference (CD) values were calculated wherever the 'F' test was found significantly. The mean values were subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom.

3. Results and Discussion

3.1 Yield attributes

3.1.1 No. of grain rows cob^{-1}

Irrigation scheduled at all the crop growth stages recorded significantly higher number of grain rows per cob (15.2) compared to rest of the treatments except those, in which moisture stress was induced by skipping irrigation only at tasseling (14.0), only at silking (14.2) and only at milky stage (14.9) and are statistically on par with each (Table 1). This is due to recovery of maize crop from the short period moisture stress at the root zone, with the irrigation provided at the succeeding stage. Irrigating upto knee high stage recorded significantly lower grain rows per cob (12.0). However, it was statistically on par with moisture stress induced at all critical stages (12.1) and at both tasseling and silking stage (13.1). This might be due to prolonged moisture stress at the root zone which resulted in poor fertilization and lessened silk receptivity to pollen ultimately reduced the grain rows per cob. These results consistent with the findings of Sunnethadevi and Praveenrao [14] who recorded significantly higher test weight with irrigations up to vegetative period.

Table 1: Yield attributes of maize in response to induced moisture stress at critical crop growth stages

Treatments	No. of grain rows cob^{-1}	No. of grains row^{-1}	No. of grains cob^{-1}	Test weight (g)	Cob weight (g)	Grain weight per cob (g)	Shelling percentage
T_1:Irrigations at VE, V4, V8, VT, R1, R3 and R4	15.2^{a}	33.6^{a}	509.6^{a}	34.6^{a}	174.8^{a}	130.1^{a}	74.5^{a}
T_2:Irrigations at VE, V4, V8, R1, R3 and R4 (Skipping VT)	14.0^{abc}	27.7^{bc}	386.1^{c}	30.5^{bc}	164.5^{b}	118.8^{b}	72.2^{ab}
T_3:Irrigations at VE, V4, V8, VT, R3 and R4 (Skipping R1)	14.2^{abc}	28.2^{bc}	400.9^{c}	30.9^{bc}	165.2^{b}	119.3^{b}	72.3^{ab}
T_4:Irrigations at VE, V4, V8, VT, R1 and R4 (Skipping R3)	14.9^{ab}	31.1^{ab}	463.3^{b}	32.3^{ab}	170.0^{ab}	124.4^{ab}	73.1^{ab}
T_5:Irrigations at VE, V4, V8, R3 and R4 (Skipping VT and R1)	13.1^{cd}	22.7^{d}	297.1^{e}	26.7^{de}	142.2^{d}	98.5^{d}	69.3^{cd}
T_6:Irrigations at VE, V4, V8, R1 and R4 (Skipping VT and R3)	13.6^{bc}	25.9^{cd}	350.3^{d}	28.8^{cd}	153.4^{c}	109.2^{c}	71.2^{bc}
T_7:Irrigations at VE, V4, V8, VT and R4 (Skipping R1 and R3)	13.5^{bc}	24.5^{cd}	330.8^{d}	28.1^{cd}	150.7^{c}	106.9^{c}	71.0^{bc}
T_8:Irrigations at VE,V4,V8 and R4 (Skipping VT, R1 and R3)	12.1^{d}	13.2^{e}	160.5^{f}	24.5^{e}	123.9^{e}	84.3^{e}	68.0^{d}
T_9: Irrigations at VE, V4 and V8. (Skipping VT, R1, R3 and R4)	12.0^{d}	12.9^{e}	153.5^{f}	24.4^{e}	123.2^{e}	83.7^{e}	67.9^{d}
S.Em.±	1.47	0.43	10.3	0.9	2.7	2.4	0.8

Means followed by same letter (s) within a column are not significantly different by DMRT

3.1.2 No. of grains row^{-1}

Significantly higher number of grains per row (33.6) than rest of the treatments was recorded with irrigations at all crop growth stages (Table 1). However, it was on par with irrigation skipped only at milky stage (31.1). Significantly lower number of grains per row was recorded with irrigation upto knee high stage (12.9) and it was on par with irrigation scheduled at emergence stage, four leaf stage, knee high stage and dough stage only (13.2). Due to severe moisture deficit at the crop root zone which reduced translocation of photosynthates from source to sink and caused kernel abortion. These findings are in conformity with the findings of Sah *et al.* [9] and Soler *et al.* [11].

3.1.3 No. of grains cob^{-1}

Among different stages of skipping irrigation, irrigation scheduled at all crop growth stages recorded significantly higher number of grains per cob (509.6) over rest of the treatments (Table 1.) Irrigation scheduled upto knee high stage recorded significantly lower number of grains per cob (153.5) and it was statistically on par with moisture stressed at tasseling, silking, and milky stage (160.5). Moisture availability at the milky stage decides the grain size and consistency. Also moisture availability in tasseling and silking stage define the grain number per cob. Due to severe moisture stress at all these critical stages grain number per cob declined significantly. Similar findings are reported by Ge Sui *et al.* [10] and Vazirimehr *et al.* [15] who reported lower kernel number per cob due to moisture stress at critical stages.

3.1.4 Test weight

Among different stages of skipping irrigation, significantly higher test weight (34.6 g) was recorded with irrigations at all crop stages than rest of the treatments (Table 1). However it was statistically on par with moisture stress only at milky stage (32.3 g). Irrigation scheduled up to knee high stage recorded significantly lower test weight (24.4 g) and it was on par with skipping irrigation at all three critical crop growth stages (24.5 g) and at both tasseling and silking stage (26.7 g). It might be due to severe moisture stress which had reduced kernel size, translocation of energy reserves, grain consistency and more no. of shriveled grains which ultimately reduced the grain weight and quality. These results are in line with the findings of Sunnethadevi and Praveenrao [14] who recorded significantly lower test weight with irrigations up to vegetative period.

3.1.5 Cob weight

Cob weight (g) as influenced by moisture stress at critical crop growth stages is presented in Table 1. Among various irrigation schedules at critical crop growth stages, irrigation at all the crop growth stages recorded significantly higher cob weight (174.8 g) compared to rest of the treatments except with skipping of irrigation only at milky stage (170.0 g). Significantly lower cob weight (123.2 g) was recorded with irrigations upto knee high stage. However, it was statistically on par with irrigation skipped at all critical stages (123.9 g). This might be due to severe moisture stress in the canopy which reduced the photosynthesizing capacity, translocation of accumulated energy reserves as well as fertilization. Similar findings are reported by Sellamuthu *et al.* [16] and Soler *et al.* [11] who recorded declined cob weight due to severe moisture stress.

3.1.6 Grain weight per cob

Significantly higher grain weight per cob (130.1 g) was recorded with irrigation scheduled at all crop growth stages than other treatments (Table 1). However it was statistically on par with the irrigation skipped only at milky (124.4 g). Irrigation scheduled upto knee high stage recorded significantly lower grain weight per cob (83.7 g) and it was statistically on par with irrigations skipped at all critical stages (84.3 g). Due to poor silk receptivity to pollen because of reduced water potential this led to kernel abortion. Hence the grain weight per cob is declined. These results consistent with the results of Ge *et al.* [10] and Kamara *et al.* [17] who reported reduced significant reductions in kernel weight per cob due to water stress.

3.1.7 Shelling percentage

The data on shelling percentage as influenced by moisture stress at critical crop growth stages is presented in Table 1. Irrigating at all crop growth stages recorded significantly higher shelling percentage (74.5%) over rest of the treatments. However, it was statistically on par with irrigation skipped only at tasseling (72.2%), only at silking (72.3%) and only at milky stage (73.1%). Significantly lower shelling percentage was recorded with irrigations upto knee high stage (67.9%). However, it was statistically on par with irrigation skipped at tasseling, silking and milky stages (68.0%). It is due to more no of shriveled and unfilled grain rows per cob. Similar findings are reported by Sellamuthu *et al.* [16] and Kamara *et al.* [17].

3.2 Yield of maize

3.2.1 Kernel yield

Irrigations at all the crop growth stages recorded significantly higher kernel yield (7040.7 kg ha^{-1}) than rest of the treatments (Table 2). These findings are in conformity with the findings of Gouranga and Verma [18] who recorded significantly higher yield by scheduling irrigation at all crop growth stages. Skipping of irrigation only at tasseling and only at silking stages recorded significantly lower yield (5744.7 and 5874.7 kg ha^{-1} respectively) than irrigation at all growth stages. Reduction in yield due to moisture stress at tasseling stage might be due to improper anthesis and reduced pollen viability which in turn due to increased temperature in micro climate of the crop. Reduced pollen viability affects fertilization ultimately and results in reduced filled grains per cob. Moisture stress at silking stage lead to higher yield reduction because, the silk which is attached to an ovule outside the husk has to be receptive to receive the pollen and turns into brown indicates successful fertilization. Silk elongation requires high water potential. Therefore, stress at this stage affects the silk length and its receptivity of pollen there by fertilization gets affected which in turn causes kernel abortion i.e. scattered and improper filling of grains on the cob. Similar findings are reported by Liang *et al.* (8) who reported 50% yield reduction due to skipping of irrigation at silking stage. Skipping irrigation at both tasseling and silking stages recorded significantly lower yield (3681.3 kg ha^{-1}) than skipping either at tasseling or at silking stage (Table 2). Skipping at both tasseling and silking recorded higher yield reduction since these two growth stages decides kernel number per cob. Kernel abortion was severe due to cumulative effect of water stress at these two stages compared to the other combinations. Similar results were reported by Yildirim *et al.* [19] who recorded yield reduction of 25.2 percent by skipping irrigation at both tasseling and silking. Irrigations upto knee high stage recorded significantly lowest yield (2628.3 kg ha^{-1}). However it was on par with irrigation skipped at tasseling, silking and milky stage (2729.7 kg ha^{-1}). Higher kernel yield reduction (62.7%) was recorded with irrigations upto knee high stage (Table 2) followed by skipping irrigation at all critical stages recorded the next highest kernel yield reduction (61.2%). This is due to lack of efficient fertilization as well as translocation of the carbohydrates from source to sink due to inadequate moisture at the root zone resulted in drastic reduction of cob size with few filled grains which in turn contributed for poor yields. These results consistent with the results of Mageto *et al.* [7] who reported yield reduction upto 90% based on the growth stage and duration of stress.

3.2.2 Stover yield

Significantly higher stover yield (9108.8 kg ha^{-1}) was recorded with scheduling of irrigations at all crop growth stages than rest of the treatments (Table 2). However it was on par with irrigation skipped only at tasseling (8468.6 kg ha^{-1}), only at silking (8596.0 kg ha^{-1}) and only at milky stage (8896.6 kg ha^{-1}). These results consistent with the findings of Igbadun *et al.* [20] who also recorded significantly higher stover yield with irrigations at all crop growth stages compared to water deficit at two stages and it was on par with water deficit only at one crop growth stage. Significantly lower stover yield (5208.2 kg ha^{-1}) was recorded with irrigations upto knee high stage and it was on par with irrigation skipped at both tasseling and silking stages (6357.2 kg ha^{-1}) and at all critical stages (5318.2 kg ha^{-1}). Due to decline in root zone soil moisture content beyond permanent wilting point reduced the rate of photosynthesis and photosynthetic area for light interception. Thereby lower accumulation of dry matter in turn contributing to lower stover yield similar findings are reported by Sellamuthu *et al.* [16].

3.2.3 Harvest index: Harvest index as influenced by moisture stress at critical crop growth stages is presented in Table 2. Scheduling irrigations at all crop growth stages recorded significantly the highest harvest index (43.8%) over rest of the treatment except those treatments where irrigation skipped only at tasseling (40.5%), only at silking (40.6%) and only at milky stage (41.9%). Significantly lower harvest index (33.5%) was recorded with irrigations upto knee high stage and it was on par with irrigation skipped at tasseling and silking (36.7%), at tasseling and milky stage (37.5%), at silking and milky stage (37.2%) and at tasseling, silking and milky stage (33.8%).

Table 2: Yield of maize as influenced by induced moisture stress at critical crop growth stages

Treatments	Kernel yield (kg ha^{-1})	Reduction in kernel yield (%)	Stover yield (kg ha^{-1})	Harvest index (%)
T_1:Irrigations at VE, V4, V8, VT, R1, R3 and R4	7040.7^{a}	-	9108.8^{a}	43.8^{a}
T_2:Irrigations at VE, V4, V8, R1, R3 and R4 (Skipping VT)	5744.7^{c}	18.4	8468.6^{a}	40.5^{ab}
T_3:Irrigations at VE, V4, V8, VT, R3 and R4 (Skipping R1)	5874.7^{c}	16.6	8596.0^{a}	40.6^{ab}
T_4:Irrigations at VE, V4, V8, VT, R1 and R4 (Skipping R3)	6411.0^{b}	9.0	8896.6^{a}	41.9^{a}
T_5:Irrigations at VE, V4, V8, R3 and R4 (Skipping VT and R1)	3681.3^{e}	47.7	6357.2^{bc}	36.7^{bc}
T_6:Irrigations at VE, V4, V8, R1 and R4 (Skipping VT and R3)	4271.3^{d}	39.3	7108.6^{b}	37.5^{bc}
T_7:Irrigations at VE, V4, V8, VT and R4 (Skipping R1 and R3)	4016.0^{de}	43.0	6808.7^{b}	37.2^{bc}
T_8:Irrigations at VE,V4,V8 and R4 (Skipping VT, R1 and R3)	2729.7^{f}	61.2	5318.2^{c}	33.8^{c}
T_9: Irrigations at VE, V4 and V8. (Skipping VT, R1, R3 and R4)	2628.3^{f}	62.7	5208.2^{c}	33.5^{c}
S.Em.±	171.6	-	356.5	1.2

Means followed by same letter (s) within a column are not significantly different by DMRT

Table 3: Economics of maize as influenced by moisture stress at critical crop growth stages

Treatment details	Cost of Cultivation (₹ ha^{-1})	Gross monetary returns (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	Benefit- cost ratio
T_1: Irrigations at VE, V4, V8, VT, R1, R3 and R4	45,462.5	1,44,514^{a}	99,052^{a}	3.18^{a}
T_2:Irrigations at VE, V4, V8, R1, R3 and R4 (Skipping VT)	45,042.5	1,18,638^{c}	73,596^{c}	2.63^{c}
T_3:Irrigations at VE, V4, V8, VT, R3 and R4 (Skipping R1)	45,042.5	1,21,278^{c}	76,236^{c}	2.69^{c}
T_4:Irrigations at VE, V4, V8, VT, R1 and R4 (Skipping R3)	45,042.5	1,32,012^{b}	86,969^{b}	2.93^{b}
T_5:Irrigations at VE, V4, V8, R3 and R4 (Skipping VT and R1)	44,622.5	76,678^{e}	32,055^{e}	1.72^{e}
T_6:Irrigations at VE, V4, V8, R1 and R4 (Skipping VT and R3)	44,622.5	88,780^{d}	44,157^{d}	1.99^{d}
T_7:Irrigations at VE, V4, V8, VT and R4 (Skipping R1 and R3)	44,622.5	83,560^{de}	38,938^{de}	1.87^{de}
T_8:Irrigations at VE,V4,V8 and R4 (Skipping VT, R1 and R3)	44,202.5	57,279^{f}	13,076^{f}	1.30^{f}
T_9: Irrigations at VE, V4 and V8. (Skipping VT, R1, R3 and R4)	43,782.5	55,214^{f}	11,481^{f}	1.26^{f}
S.Em.±	-	3383.3	3383.3	0.08

Means followed by same letter (s) within a column are not significantly different by DMRT

3.3 Economics

Significantly higher gross monetary returns (₹1,44,514 ha^{-1}), net monetary returns (₹ 99,052 ha^{-1}) and benefit- cost ratio (3.18) was obtained with irrigations scheduled at all crop growth stages due to higher kernel yield and stover yield over rest of the treatments (Table 3). Followed by skipping irrigation only at milking stage recorded the next highest gross monetary returns (₹1,32,012 ha^{-1}), net monetary returns (₹ 86,969 ha^{-1}) and benefit- cost ratio (2.93). Similar results were reported by Rudragouda *et al.* (21) who also recorded significantly higher gross income, net income and benefitcost ratio with total of seven irrigations during crop growing period. Significantly lower gross monetary returns (₹55,213.7 ha^{-1}), net monetary returns (₹11,481 ha^{-1}) and benefit cost ratio (1.26) was obtained with irrigation up to knee high stage due to lower grain yield and stover yield. Moisture deficiency at the crop root zone was due to skipping of irrigation from knee high stage which has affected plant growth and development contributed to poor yields. These results are harmonious with the findings of Raibagi [22] who recorded significantly lower gross income, net income and benefit-cost ratio with scheduling irrigation only in vegetative period up to twelve leaf stage.

4. Conclusion

Irrigation scheduled at all crop growth stages recorded significantly higher yield due to significantly higher number of rows per cob, number of kernels per row, number of kernels per cob, cob weight, grain weight per cob, test weight, shelling percentage and stover yield. Irrigation skipped only at tasseling, only at silking and only at milky stages recorded yield reduction of 18.4, 16.6 and 9.0 percent respectively whereas skipping of irrigation at tasseling and silking, at tasseling and milky stage and at silking and milky stages recorded 47.7, 43.0 and 39.3 percent yield reduction respectively compared to irrigation at all growth stages . Skipping irrigation at tasseling, silking and milky stage recorded yield reduction of 61.2 percent and irrigation up to knee high stage recorded a yield reduction of 62.7 percent compared to the irrigation at all crop growth stages. Significantly higher gross monetary returns net monetary returns and benefit- cost ratio was obtained by scheduling irrigations at all crop growth stages due to higher kernel yield and stover yield over rest of the treatments. Next best returns were obtained from skipping irrigation only at milky stage.

5. Acknowledgement

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6. Conflict of interest

Authors declare no conflict of interest exists.

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