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IMPACT OF SPACING AND IRRIGATION REGIMES ON GROWTH, FORAGE YIELD, NUTRITIONAL STATUS, AND WATER USE EFFICIENCY OF BABY CORN (*ZEA MAYS* L.)

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SUMMARY

A field experiment was conducted in Spring season of 2019 at Hisar, Haryana to investigate the effect of different spacing and irrigation regimes on baby corn (*Zea mays* L.). The experiment was laid out in split-plot design with four irrigation treatments *viz*. one irrigation - 6 leaf stage, two irrigation - 6 leaf and knee high stage, two irrigation - knee high and pre-tasselling stage and three irrigation - 6 leaf, knee high and pre-tasselling stage in main plots and four spacing treatments *viz*. 60 cm × 20 cm, 60 cm × 15 cm, 45 cm × 20 cm and 45 cm × 15 cm in sub-plots. The experiment results showed that three irrigation treatment – (first irrigation at 6 leaf, second at knee high and third at pre-tasselling stage) observed significantly higher plant population, plant height and dry matter accumulation. Maximum fodder yield (254.55 q/ha), nutrient content in fodder (1.83% N, 0.39 %P, 2.28 %K) and nutrient uptake in fodder (34.36 N, 5.94 P, 42.50 K kg/ha, respectively) was found in three irrigation at 6 leaf, knee high and pre-tasselling stage over other treatments. Water use efficiency by fodder yield (387.02 kg/ha-mm) was found maximum in one irrigation at 6 leaf stage. In spacing treatments, maximum fodder yield (262.67 q/ha), nutrient content in fodder (1.79% N, 0.38% P, 2.23% K) and nutrient uptake in fodder (41.07 N, 5.56 P, 50.48 K kg/ha, respectively) was found in 45 cm × 15 cm spacing over other treatments. Water use efficiency by fodder yield (234.65 kg/ha-mm) was found maximum in 45 cm × 15 cm spacing. Maximum green fodder yield was recorded in the treatment where three irrigations were applied (at 6 leaf, knee high and pre-tasselling stage) with the crop geometry of 45 cm × 15 cm.

Key words: Baby corn, spacing, irrigation regimes, green fodder yield, nutrient content and uptake

Maize (*Zea mays* L.) is the world's third most vital crop after rice and wheat in the world agricultural economy both in terms of food and feed. It accounts for 18% of cereal acreage, 25% of productivity and 28% of production of the world. India ranks sixth in production and fourth in area. Maize is one most important crops for human and animal consumption and is grown for both grain and silage (Shweta *et al*., 2022b). Maize is cultivated for some special purposes like baby corn, sweet corn and popcorn purpose. It shows great adaptability to wide ranges of agro-climatic regions and is suitable to be grown in all the three seasons *viz., summer/spring, kharif and rabi*. Baby corn is harvested within 2-3 days after silk emergence and no grain development (Shweta *et al*., 2017). One of the most adaptable emerging crops is maize (*Zea mays* L.), which can be successfully grown in a variety of seasons and ecologies and used for a variety of purposes (Anu *et al*., 2023a). Considering that it has the largest genetic production potential of all the cereals, maize is referred to as the "Queen" of cereals internationally. Modern corn production systems frequently see greater plant-to-plant variability as a result of increased competition for scarce resources among individual plants at ever larger plant densities (Kumar *et al*., 2020). With a huge shortage of 62 and 22% of both green and dry fodder, respectively, the country's current feed and fodder supplies can only cover 47% of the requirements (Meena *et al.,* 2022 and Sewhag *et al*., 2022). It has by-products such as tassel, young husk, silk, and green stalks provide good cattle feed, which is also very nutritious. Baby corn cob also free from pesticides, insecticides, and herbicides residues (Shweta *et al*., 2022b).

Crop yield depends on plant morphology, planting time, manure, and water requirement. The optimum plant population utilizes proper underground resources with maximum solar radiation (Sewhag *et al*., 2021). The available space to the individual plant determines the use of existing resources in the soil laterally with the interception of solar radiation, and

both decide on the yield of baby corn. Maximum baby corn yield could be achieved by gaining maximum energy potential. Therefore, establishing the optimum crop geometry for the region is of great importance.

In spring season (February to March), crop water requirement increases with an increase in temperature. Precision water management can not only increase water efficiency but also help improve the growth and development of plants by ensuring optimal soil moisture across the growing season with lower environmental impacts. Moisture stress contributes to lower crop population and low leaf area index, resulting in poor grain and fodder maize yields. While excess soil moisture availability causes poor plant geometry as well as stunted plant growth. In this sense, the judicial application of water at the right time and with proper quantity, as well as the retention of soil moisture for longer periods, is of prime importance. Inadequate irrigation and low plant population are the major factors limiting grain yield of maize in many areas. Planting geometry and water management play an important role in enhancing the crop productivity. Considering the above view, research on the effects of different spacing and irrigation regimes on baby corn output is limited. As a result, the current experiment was designed to investigate the influence of various irrigation levels and planting geometry on the fodder yield of baby corn.

MATERIALS AND METHODS

A field experiment was conducted during spring season, 2019 at the Research Farm, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar which is situated at 29°10′ North latitude, 75°36′ East longitude and at the elevation of 215.2 m above mean sea level under subtropical climate in India to investigate the effect of different spacing and irrigation regimes on growth and yield of spring's baby corn. In the agricultural season of spring 2019, a cumulative precipitation of 19.4 mm occurred from February to May. During the study, the average highest and lowest temperatures per week varied from 22.6 to 41.4 °C and 7.8 to 24.5 °C, respectively, during the crop growth season. The average relative humidity during the morning hours varied between 44.13% and 87.88%, while during the evening hours it ranged from 18.74% to 47.94%. The wind speed ranged from 2.4 to 7.7 km/h, the sunlight hours ranged from 2.1 to 11.3 hour per day, and the pan evaporation ranged from 0.8 to 3.0 mm per day (Fig. 1). The mean weekly maximum and minimum temperature ranged from 22.6 to 41.4°C and 7.8 to 24.5°C, respectively during crop growing period. The soil of the experimental field was sandy loam in texture with pH 8.0, organic carbon (0.33%) and available N, P and K contents were 140, 15.1 and 272.3 kg ha^{-1} respectively.

The experiment was laid out in split-plot design and replicated thrice. Main plot treatments consisted of four irrigation treatments (one irrigation - 6 leaf stage, two irrigation - 6 leaf and knee high stage, two irrigation - knee high and pre-tasselling stage and three irrigation - 6 leaf, knee high and pre-tasselling stage) and sub-plots consisted of four spacing treatments (60 cm × 20 cm, 60 cm × 15 cm, 45 cm × 20 cm and 45 cm × 15 cm). Recommended doses of N and P @ 120:60 kg ha^{-1} were applied in the form of urea and diammonium phosphate, respectively as basal dose. The half dose of N was applied as basal and remaining half dose was applied at 25-30 days after sowing, depending on the availability of the soil moisture. The potash was not applied since the soil of the experimental field was rich in available potassium.

Baby corn variety 'Hybrid baby corn (G-5414)' was sown in last week of February, 2019 with 6 m × 2.5 m plot size. Plant protection measures and other cultural operations were carried out in accordance with the package of practices of CCS HAU, Hisar. The harvesting of baby corn was started from 1st week of May onwards by four pickings in 5-6 days' interval. The growth parameters like plant height, dry matter accumulation etc. were recorded periodically. Observations on yield was recorded at the time of harvest. According to the treatments, three irrigations were applied in baby corn at 6 leaf stage, knee high stage and pre-tasseling stage that differs according to the given treatments. The total rainfall during the crop growth period was 19.4 mm (Feb-May). The water use efficiency (WUE) was measured by calculating the ratio of the economic crop yield obtained to the amount of water required for crop growth. It was computed by the formula given below:

$$WUE = \frac{Y}{WR}$$

Where, WUE = Water use efficiency (kg/ha-mm), Y = Yield (kg/ha) and WR = Water used (mm)

The nutrient uptake was calculated by multiplying the content of nitrogen, phosphorus and potassium, respectively with their respective dry matter yield and expressed in kg/ha. Standard techniques were used to statistically analyse the data and interpret the results.

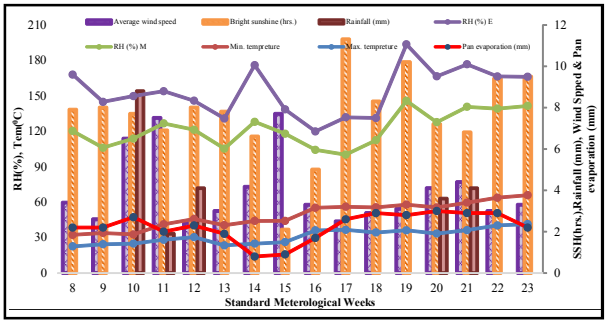


Fig. 1. Weekly meteorological data at Hisar during Spring 2019.

RESULTS AND DISCUSSION

Effect of irrigation

The data presented (Table 1) revealed that the plant population at 20 DAS was found non-significant due to different irrigation treatments. While maximum plants per meter was found under the irrigation at 6-leaf stage, knee-high stage and pre-tasselling stage. Plant height and dry matter accumulation at 40, 60 DAS and at harvest were recorded higher in three irrigation at 6 leaf, knee high and pre-tasselling stage irrigation treatment as compared to other treatments. This might be ascribed to rapid meristematic cell division and cell elongation because water acts as a channel for dissolving nutrients in soil and shorter plant height in further treatments was due to moisture stress which leads to poor cell elongation (Roy *et al*. (2015).

The data presented (Table 2) revealed that three irrigation at 6 leaf, knee high and pre-tasselling stage recorded the highest fodder yield (254.55 q/ha) which was significant over other treatments. The increase in fodder yield might be because of better vegetative growth and higher dry matter production. Similar findings were also confirmed by Meena *et al.,* (2022). The data presented in (Fig. 2) revealed that the highest WUE fodder yield (387.02 kg/ha/mm) was recorded with one irrigation at the 6-leaf stage. Lowest WUE with fodder yield (128.08 kg/ha/mm) was observed in three irrigation at 6 leaf, knee high and pre-tasselling stage. This was because of increased water supply that resulted in an increased rate of evapotranspiration, might be due to the proportionate increase in yield being less than the increase in irrigation and evaporation losses.

Effect of spacing

The data presented (Table 1) revealed that plant population at 20 DAS, plant height and dry matter accumulation at 40, 60 DAS and at harvest were recorded higher in the 45 cm × 15 cm spacing treatment as compared to other treatments. This may be due to the narrow spacing obtained maximum plants per unit area as compared to wider spacing. In narrow spacing, number of plants per unit area was maximum (Anu *et al.,* 2023a).

Higher plant height and dry matter accumulation in 45 × 15 cm spacing treatment might be due that, at closer crop geometry, more severe competition for light and higher intra and inter-row

TABLE 1
Effect of different spacing and irrigation regimes on growth attributes of baby corn fodder.

Treatments	Plant population 20 DAS (No /mrl)	Plant height (cm)			Dry matter accumulation (g/plant)		
		40 DAS	60 DAS	At harvest	40 DAS	60 DAS	At harvest
Irrigation							
One irrigation (6 leaf stage)	4.85	73.10	163.08	168.90	5.41	14.71	15.37
Two irrigation (6 leaf stage and knee high stage)	4.82	73.25	170.70	173.70	5.15	16.32	16.67
Two irrigation (knee high stage and pre-tasseling stage)	4.90	69.87	168.70	174.99	5.45	15.60	17.07
Three irrigation (6 leaf stage, knee high stage and pre-tasseling stage)	5.05	73.67	170.99	175.72	5.46	16.34	17.28
S.Em. ±	0.18	0.45	1.38	1.40	0.04	0.12	0.16
C.D. (p=0.05)	NS	1.59	4.88	4.92	0.15	0.43	0.48
Spacing							
60 × 20 cm	4.33	71.22	164.68	169.68	5.25	15.40	16.29
60 × 15 cm	4.61	72.54	167.45	172.45	5.37	15.65	16.31
45 × 20 cm	5.19	72.85	167.80	172.80	5.37	15.69	16.60
45 × 15 cm	5.50	74.27	173.75	177.75	5.48	16.23	17.05
S.Em. ±	0.21	0.57	1.30	1.32	0.04	0.11	0.12
C.D. (p=0.05)	0.64	1.69	3.81	3.90	0.13	0.34	0.35

TABLE 2
Effect of different spacing and irrigation regimes on nutrient content and uptake in fodder baby corn.

Treatment	Green fodder yield (q/ha)	Nutrient content (%)			Nutrient uptake (kg/ha)		
		N	P	K	N	P	K
Irrigation							
One irrigation (6 leaf stage)	241.46	1.70	0.35	2.08	30.72	4.93	37.54
Two irrigation (6 leaf stage and knee high stage)	243.64	1.70	0.35	2.09	30.93	4.96	37.94
Two irrigation (knee high stage and pre-tasseling stage)	249.98	1.76	0.37	2.18	34.16	5.47	42.30
Three irrigation (6 leaf stage, knee high stage and pre-tasseling stage)	254.55	1.83	0.39	2.28	34.26	5.94	42.50
S.Em. ±	1.92	0.01	0.003	0.01	0.94	0.08	1.17
C.D (p=0.05)	5.65	0.05	0.009	0.05	3.34	0.29	4.12
Spacing							
60 × 20 cm	235.67	1.71	0.36	2.10	25.84	5.03	32.02
60 × 15 cm	242.16	1.73	0.36	2.13	31.16	5.33	38.31
45 × 20 cm	249.57	1.77	0.37	2.18	32.00	5.37	39.45
45 × 15 cm	262.67	1.79	0.38	2.23	41.07	5.56	50.48
S.Em. ±	2.68	0.01	0.002	0.01	0.56	0.04	0.69
C.D (p=0.05)	9.24	0.03	0.006	0.04	1.64	0.13	2.20

competition for nutrients and water due to overcrowding of plants might be responsible for increasing the plant height. Similar results were also reported by Gaikwad *et al.* (2015), Bairagi *et al.* (2015), Devi and Ghosh (2017) and Anu *et al.* (2023b).

The data presented (Table 2) revealed that the spacing treatment, 45 cm × 15 cm recorded the highest fodder yield (262.23 q/ha) which was significant over other treatments. This might be due to closer spacing due to more number of plants per unit area and also contributing growth parameters *i.e.* plant height and dry matter accumulation [Sarkar *et al.* (2020) and Anu *et al.*, 2023 b].

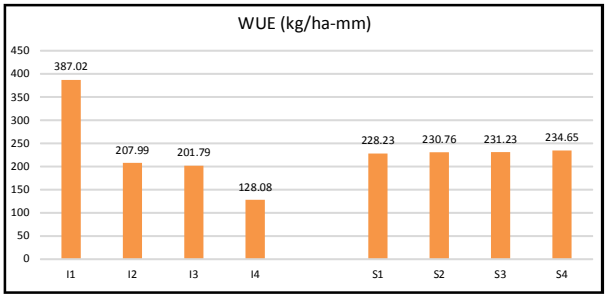
The data presented in (Fig. 1) revealed that the highest WUE with fodder yield (228.23 kg/ha/mm) was recorded with treatment 60 cm × 20 cm. The lowest WUE with fodder yield (230.76 kg/ha/mm) was observed in treatment 45 cm × 15 cm. This might be due to the high plant population using more water as compared to less plant population (Reddy *et al.*, 2018). In fodder, crops planted at spacing 45 cm × 15 cm accumulated significantly higher nitrogen (1.79 %) being at par with 45 cm × 20 cm (1.77 %) spacing. Baby corn planted under 45 cm × 15 cm recorded maximum nutrient content (0.38 % P & 2.23% K) significantly higher than other spacing treatments. Crop planted at spacing 45 cm × 15 cm accumulated significantly higher nitrogen, phosphorus and potassium uptake (25.04 kg/ha, 6.20 kg/ha, 7.79 kg/ha) significantly higher than other spacing treatments. More nutrient uptake by plant with optimum row spacing was due to better root growth ultimately producing higher growth and yield attributes. Higher yield attributes of baby corn under optimum row spacing due to better availability of resources also noted by Dutta *et al.* (2015).

The interaction effect of different spacing and irrigation regimes shows maximum fodder yield (279.18 q/ha) in 45 cm × 15 cm and three irrigations at 6-leaf, knee high and pre-tasseling stage. This may be due to the higher plant population and efficient use of water by plants.

The data presented in (Table 2) revealed that the highest accumulated nutrient content in fodder (1.83% N, 0.39% P, 2.28% K) was estimated with three irrigations (at 6 leaf, knee high and pre-tasselling stage). The highest nutrient uptake in fodder (34.36 N, 5.94 P, 42.50 K kg/ha, respectively) was recorded with three irrigations (at 6 leaf, knee high and pre-tasselling stage) over other treatments. The observed

TABLE 3
Interaction effect of different spacing and irrigation regimes on fodder yield (q/ha) of baby corn

Treatments	Green fodder yield (q/ha)				
	I_1	I_2	I_3	I_4	Mean
S_1	231.42	234.06	236.76	240.46	235.67
S_2	242.91	240.52	241.43	243.80	242.16
S_3	247.63	246.52	250.03	254.13	249.57
S_4	243.93	253.50	271.70	279.18	262.67
Mean	241.46	243.64	249.98	254.55	
Int. I × S	12.18				
Int. S × I	13.41				



I_1: one irrigation - 6 leaf stage, I_2: two irrigation - 6 leaf and knee high stage, I_3: two irrigation - knee high and pre-tasselling stage I_4: three irrigation - 6 leaf, knee high and pre-tasselling stage, S_1: 60 × 20 cm, S_2: 60 × 15 cm, S_3: 45 × 20 cm, S_4: 45 × 15 cm, WUE: water use efficiency.

Fig. 2. Effect of different spacing and irrigation regimes on water use efficiency (WUE) in baby corn.

decrease in total NPK uptake might be due to reduced moisture level [Dutta *et al.* (2015) and Shruti *et al.* (2018)].

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