Mysore J. Agric. Sci., 56 (4) : 155-166 (2022)

Effect of Sensor Based Irrigation and Nutrient Management on Growth, Yield Attributes and Yield of Baby Corn (*Zea mays* L.)

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Received : October 2022

Accepted : November 2022

ABSTRACT

A field experiment on sensor based irrigation and nitrogen management in baby corn (*Zea mays* L.) was carried out during summer 2021 and 2022 at L Block, GKVK, Bengaluru, consisting of three levels of irrigation as main plot treatment with five sub plots of nutrient management practices. The experiment was laid out in a split plot design. The results of pooled data revealed that IoT based drip irrigation at 50 per cent DASM along with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} recorded significantly higher plant height at 45 and at harvest (148.6 and 177.1 cm, respectively), leaf area at 45 DAS and at harvest (4659 and 9267 cm^2 plant^{-1}, respectively), number of cobs (3.4 cob plant^{-1}), husked cob weight (90.4 g plant^{-1}), dehusked cob weight (21.9 g plant^{-1}), husked cob yield (218.5 q ha^{-1}) and dehusked cob yield (85.5 q ha^{-1}) compared to treatment receiving surface irrigation with recommended dose of fertilizer which recorded plant height of 105 and 123.7 cm, at 45 DAS and at harvest, leaf area of 2472 and 5980 cm^2 plant^{-1}at 30, 45 DAS and at harvest, number of cobs (2 cob plant^{-1}), husked cob weight (64.9 g plant^{-1}), dehusked cob weight (15.7 g plant^{-1}), husked cob yield (129.7 q ha^{-1}) and dehusked cob yield (42.2 q ha^{-1}).

Keywords : Sensor, Babycorn, Site specific nutrient management, Soil test crop response, GreenSeeker

MAIZE is the third most important cereal crop next to rice and wheat in India and an important cereal in global agricultural economy. There are different types in maize *viz*., dent corn, sweet corn, pop corn and baby corn. For diversification in value addition and for food processing industries, recent development is of growing maize for vegetable purpose, which is commonly known as baby corn (*Zea mays* L.). Baby corn is the dehusked young cob of maize harvested within 2-3 days of silk emergence. As a C4-plant, it is an efficient converter of absorbed nutrients into food. Baby corn has high contents of folate as well as vitamin B and is a good source of several other nutrients (Singh *et al*., 2010). Water and nutrients play a very important role in baby corn growth and productivity because of the high plant density and the extremely short life cycle of baby corn. The spatial and temporal variability in rainfall and groundwater depletion has been a challenge for the sustainability of crop production (Patil *et al*., 2012 and Sah *et al*., 2020). Water scarcity is becoming more and more serious globally as a result of climate change and population increase. The freshwater demand for domestic use is growing at a rapid rate, and about 91 per cent is used for agriculture (Kayatz *et al*., 2019).

Therefore, appropriate irrigation practices are required to minimise water loss and increase WUE. In this context, several management practices have been tried in baby corn to manipulate soil moisture content and increase input use efficiency, in summer-grown baby corn. Modifications in irrigation levels certainly influence the crop growth, phenological stages, cob length, cob girth and baby corn yield (Sangakkara *et al*., 2010 and Sah *et al*., 2020). Drip irrigation is chosen to optimize the usage of water resources for improving the crop yield. It is clearly seen that over the past ten years, there was a gradual decrease in the groundwater level. To use the available water resources efficiently, automation in the drip irrigation system is needed. Researchers are now concentrating on the automation of irrigation system. The game changer technology will be sensor based automation in the drip irrigation system for effective utilization of water resources. With the development of sensor based technology and network-based information technology and Internet of Things (IoT) plays a major role in precision agriculture in a larger extent (Jino and Jackuline, 2017 and Barkunan *et al*., 2019).

Fertilizers play a pivotal role in improving productivity across the spectrum of baby corn (Abebe and Feyisa, 2017). Efficient nitrogen (N) fertilization is crucial for economic baby corn production. The absorption of N by crops is variable among and between seasons, as well as between locations in the same field, even when the N supplies are high. The N supply from soil to crop varies spatially,the demand for N by the crop also varies. As a result, the crop's nutritional status is a good indicator of the necessary N rate application. Soil test crop response (STCR) approach takes into account the nutrient requirements of a crop to produce unit yield, likely contribution from soil and from the fertilizer to know fertilizer to be added for a given yield level. Similarly, Site-specific nutrient management (SSNM) approach is one such option which focuses on balanced and crop need based nutrient application (Johnston *et al*., 2009).

Green Seeker is an integrated optical sensing and application system that measures crop nitrogen status and variably applies the crop's nitrogen requirements. Yield potential for a crop is identified using a vegetative index known as NDVI (normalized difference vegetative index) and an environmental factor. These sensors use visible and near-infrared (NIR) spectral response from plant canopies to detect N stress. Chlorophyll contained in the palisade layer of the leaf absorbs 70 to 90 per cent of all incident light in the red wave length band. Reflectance of the NIR electromagnetic spectrum (720-1300 nm) depends upon mesophyll cells which scatter and reflect as much as 60 per cent of all incident NIR radiation (Puneet, 2011). Nitrogen (N) is then recommended based on yield potential and the responsiveness of the crop to additional nitrogen.

Considering the above mentioned facts the present study is planned to investigate the effect of sensor based irrigation and nitrogen management in baby corn.

Material and Methods

A field experiment on sensor based irrigation and nitrogen management in baby corn (*Zea mays* L.) was carried out during summer 2021 and 2022 at L block of Zonal Agricultural Research Station, Gandhi KrishiVignana Kendra (GKVK), University of Agricultural Sciences (UAS), Bangalore. The site of experimentation was in Agro Climatic Zone V (Eastern Dry Zone) of Karnataka, located in 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above mean sea level (MSL).The soil of the experimental site is red sandy loam with coarse sand (35.20 %), fine sand (38.70 %), Silt (7.60 %) and Clay (25.00 %) as soil components. The soil reaction was neutral (6.17) with an EC of 0.27 dS m^{-1}, medium in available nitrogen (245 kg ha^{-1}), available phosphorus (48 kg ha^{-1}) and available potassium (180 kg ha^{-1}). The experiment was laid out in split plot design. The treatment consists of three main plots and five sub plots. Main plots: I_1 - Surface Irrigation, I_2 –Yellow SMI based Drip irrigation, I_3 - IoT drip irrigation at 50 per cent DASM. Sub plots: N_1–Recommended dose of nitrogen, N_2–GreenSeeker based N application, N_3 - STCR based target yield of 10 t ha^{-1}, N_4–STCR based split application of N for targeted yield of 10 t ha^{-1}, N_5–SSNM based split application of NPK for targeted yield of 10 t ha^{-1}. The land was prepared to a fine tilth. The furrows were opened with a furrow opener

TABLE 1

Quantity of nitrogen, phosphorus and potassium calculated for Baby corn during summer 2021 and 2022

Fertilizer levels	N (kg ha^{-1})			P_2O_5 (kg ha^{-1})			K_2O (kg ha^{-1})		
	2021	2022	Average	2021	2022	Average	2021	2022	Average
N_1	150	150	150	75	75	75	40	40	40
N_2	100	100	100	75	75	75	40	40	40
N_3	280	254	267	113	113	113	96	95	955
N_4	280	261	270	113	113	113	96	95	955
N_5	263	250	256	139	100	119	220	150	185

by adjusting the width to the required row spacing of 45 cm. The calculated amounts of nutrients were applied to the respective treatments (Table 1). High yielding hybrid G5417 baby corn suitable for all seasons was selected for the study.

The irrigation was given based on the sensors data. For every treatment, water meter (hall effect sensor) was installed to measure the quantity of water flows. To measure the soil moisture instantly, resistance type single point sensors were installed in the field at a depth of 15 cm, in turn all these were connected to IoT based field controller and gateway. The drips were installed to the solenoid valve monitored system for automation.

The amount of nutrient required to achieve target yield was calculated by using the formulae for different techniques. The chemical fertilizer required for STCR treatments were calculated using soil test crop response (STCR) equations developed by UAS, Bangalore. The amount of fertilizer for site specific nutrient management treatment was calculated using SSNM equation. Based on crop removal pattern, nutrients were applied *i.e.,* to produce one tonne of maize grain we need to apply 26.3 kg N, 13.9 kg P_2O_5 and 27.3 kg K_2O. Green seeker is an optical sensor that emits and measures reflected light at two different wave lengths *viz*., one in the visible spectrum (660 nm) and another one in the near-infrared spectrum (770 nm). Measured spectral reflectance is expressed as spectral vegetation indices such as NDVI. NDVI values range from 0 to 1. If NDVI values are below 0.3 (15-30 DAS) applied 25 kg ha^{-1} nitrogen, if values are in between 0.3 to 0.5 (45- 60 DAS) applied 25 kg ha^{-1} nitrogen, if it is not in the range no nitrogen was applied and values are more than 0.7 no need to apply additional nitrogen (Puneet, 2011). The growth observations were recorded at different growth stages. The baby corn were harvested 2 days after silking, when the silk started to turn pink. The husked and dehusked yield observations were recorded.

RESULTS AND DISCUSSION

The data pertaining to plant height of baby corn at different growth stages as influenced by sensor based irrigation and nitrogen management practices are presented in Table 2.

There was no significant difference in plant height at 15 and 30 DAS among the treatments. IoT based drip irrigation at 50 per cent DASM recorded significantly higher plant height at 45 DAS and at harvest (127.9 and 150.3 cm, respectively) and was at par with yellow SMI based drip irrigation (123.1 and 144.8 cm, respectively). Surface irrigation recorded significantly lower plant height (109.5 and 128.5 cm, respectively). Significantly higher plant height at 45 and at harvest was observed with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (136.1 and 158.8 cm, respectively) followed by STCR based split application of N for targeted yield of 10 t ha^{-1} shown on par results (131.3 and 158.8 cm, respectively). Application of recommended dose nitrogen recorded significantly lower plant height (108.9 and 128.7 cm, respectively). IoT based drip irrigation at 50 per cent DASM along

TABLE 2

Plant height (cm) at different growth stages of baby corn as influenced by sensor-based irrigation and nitrogen management

Treatments	15 DAS			30 DAS			45 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mainplot (Irrigation)												
I_1	14.7	14.8	14.8	65.6	67.2	66.4	108.2	110.8	109.5	127.4	129.7	128.5
I_2	15.7	15.7	15.7	68.1	69.1	68.6	122.3	123.9	123.1	143.2	146.3	144.8
I_3	15.9	16.1	16.0	68.8	69.7	69.2	126.7	129.0	127.9	148.9	151.8	150.3
S.Em.±	0.27	0.34	0.31	0.71	0.52	0.61	2.20	2.15	2.17	2.20	2.73	2.46
CD at5%	NS	NS	NS	NS	NS	NS	8.61	8.41	8.51	8.61	10.69	9.65
Subplot (Nutrient)												
N_1	14.8	14.9	14.8	64.3	66.1	65.2	107.4	110.3	108.9	127.5	130.0	128.7
N_2	14.5	14.5	14.5	65.0	67.0	66.0	109.6	112.0	110.8	128.8	131.4	130.1
N_3	16.0	16.2	16.1	67.3	68.8	68.1	112.4	114.9	113.6	132.0	134.6	133.3
N_4	15.9	16.0	15.9	70.3	70.4	70.3	131.0	131.6	131.3	153.7	156.4	155.0
N_5	16.0	16.1	16.1	70.5	70.9	70.7	134.8	137.4	136.1	157.2	160.4	158.8
S.Em.±	0.49	0.49	0.49	2.04	1.47	1.75	2.68	2.68	2.68	2.88	2.88	2.88
CD at5%	NS	NS	NS	NS	NS	NS	7.82	7.81	7.82	8.40	8.40	8.40
Interaction (I×N)												
I_1N_1	14.7	14.8	14.8	61.0	64.0	62.5	103.3	106.7	105.0	122.9	124.4	123.7
I_1N_2	14.2	14.2	14.2	61.7	65.9	63.8	105.8	108.3	107.1	124.2	125.5	124.9
I_1N_3	14.3	14.5	14.4	65.4	67.0	66.2	105.9	108.7	107.3	125.5	127.8	126.7
I_1N_4	15.2	15.2	15.2	70.1	69.2	69.6	112.8	114.9	113.9	131.7	134.9	133.3
I_1N_5	15.3	15.3	15.3	69.6	69.8	69.7	112.9	115.7	114.3	132.5	135.7	134.1
I_2N_1	14.6	14.8	14.7	65.4	67.3	66.4	108.3	111.3	109.8	128.4	131.3	129.9
I_2N_2	14.7	14.7	14.7	66.5	66.8	66.6	110.3	113.0	111.6	130.6	134.3	132.5
I_2N_3	16.0	16.0	16.0	68.1	69.4	68.7	113.4	116.0	114.7	133.8	136.0	134.9
I_2N_4	16.5	16.5	16.5	70.0	70.6	70.3	135.0	132.7	133.8	159.3	163.3	161.3
I_2N_5	16.7	16.7	16.7	70.4	71.2	70.8	144.3	146.7	145.5	163.9	166.7	165.3
I_3N_1	15.1	15.1	15.1	66.4	67.1	66.8	110.7	113.0	111.8	131.0	134.3	132.7
I_3N_2	14.7	14.7	14.7	66.7	68.2	67.5	112.6	114.9	113.7	131.7	134.5	133.1
I_3N_3	17.7	18.0	17.8	68.5	70.0	69.2	117.9	120.0	118.9	136.7	140.0	138.4
I_3N_4	16.0	16.4	16.2	70.7	71.5	71.1	145.1	147.3	146.2	170.0	171.0	170.5
I_3N_5	16.1	16.3	16.2	71.5	71.7	71.6	147.2	150.0	148.6	175.1	179.0	177.1
S.Em.±	0.81	0.83	0.82	3.24	2.33	2.79	4.70	4.67	4.68	4.97	5.22	5.10
CD at5%	NS	NS	NS	NS	NS	NS	13.54	13.53	13.54	14.55	14.54	14.54

with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} recorded significantly higher plant height at 45 DAS and at harvest (148.6 and 177.1 cm, respectively) and it was statistically on par with IoT based drip irrigation at 50 per cent DASM along with STCR based split application of N for targeted yield of 10 t ha^{-1} (146.2 and 170.5 cm, respectively) and yellow SMI based drip irrigation with SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (145.5 and 165.3 cm, respectively). Significantly lower plant height was noticed in surface irrigation with RDN (105.0 and 123.7 cm, respectively).

The increased plant height is mainly influenced by irrigation and nutrient management practices. The continuous availability of moisture and nutrients at right time, right place in right amount close to the crop root region during the cropping period, helped in more leaf area and dry matter production which helped in increased plant height. Higher plant height was observed under sensor based automated irrigation at 50 per cent DASM because of higher nutrient uptake resulting in greater cell division and elongation. The nutrient supplied by SSNM practice will make nutrient available for crop uptake at all stages of crop growth. The above results are in accordance with the findings of Chethan, (2015), Jasim Iqbal *et al*. (2016) and Prakasha *et al*, (2020).

In surface irrigation, maximum moisture availability will be at the time of irrigation followed by intermittent dryness which might have affected physiological processes. On the other hand, severe stress imposed at surface irrigation has reduced plant height at all growth stages. The above results are in corroborative with findings of Chigign (2011), Banerjee *et al*. (2014), Hokam *et al*. (2011) and Desai and Mudalagiriyappa (2022).

The data on leaf area per plant as influenced by sensor based irrigation and nutrient management practices in baby corn are presented in Table 3.

There was no significant difference in leaf area at 15 and 30 DAS among the treatments. IoT based drip irrigation at 50 per cent DASM recorded significantly higher leaf area at 45 DAS and at harvest (3779 and 7951 cm^2 $plant^{-1}$, respectively) and it was on par with yellow SMI based drip irrigation (3580 and 7591 cm^2 $plant^{-1}$, respectively). Surface irrigation recorded significantly lower leaf area (2818.3 and 6483 cm^2 $plant^{-1}$, respectively).

Significantly higher leaf area at 45 DAS and at harvest was observed with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (4068 and 8499 cm^2 $plant^{-1}$, respectively) and it was at par with STCR based split application of N for targeted yield of 10 t ha^{-1} (3879 and 8183 cm^2 $plant^{-1}$, respectively). Application of recommended dose nitrogen recorded lower leaf area (2916 and 6303 cm^2 $plant^{-1}$, respectively) and was on par with green seeker based nitrogen application (2965 and 6461 cm^2 $plant^{-1}$, respectively). IoT based drip irrigation at 50 per cent DASM along with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} recorded significantly higher leaf area at 45 DAS and at harvest (4659 and 9267 cm^2 $plant^{-1}$, respectively) and it was statistically on par with IoT based drip irrigation at 50 per cent DASM with STCR based split application of N for targeted yield of 10 t ha^{-1} (4439 and 9183 cm^2 $plant^{-1}$, respectively) and yellow SMI based drip irrigation with SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (4304 and 9148 cm^2 $plant^{-1}$, respectively). Surface irrigation with RDN recorded significantly lower leaf area (2472 and 5980 cm^2 $plant^{-1}$, respectively).

IoT based drip irrigation at 50 per cent DASM has recorded higher number of leaves and leaf area, which clearly depicts the superiority of sensor based drip irrigation over other treatments. The higher leaf area was due to the increased plant height resulted into more number of nodes per plant leading to more number of leaves per plant. The adequate amount of soil moisture and nutrient are available for crop growth throughout growth period due to the availability of required quantity of water and nutrients during the crop period matching with the crop demand. In turn, it helped the photosynthetic area to develop and active for longer period and was responsible for total growth

TABLE 3

Leaf area (cm^2) at different growth stages of baby corn as influenced by sensor-based irrigation and nitrogen management

Treatments	15 DAS			30 DAS			45 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mainplot (Irrigation)												
I_1	32.8	33.2	33.0	1205	1262	1234	2777	2860	2818	6399	6566	6483
I_2	34.8	35.0	34.9	1267	1331	1299	3523	3637	3580	7525	7658	7591
I_3	38.7	39.4	39.1	1307	1362	1334	3731	3826	3779	7895	8007	7951
S.Em.±	1.54	1.44	1.49	20	20	20	96	98	97	121	112	116
CD at5%	NS	NS	NS	NS	NS	NS	375	382	379	473	437	455
Subplot (Nutrient)												
N_1	33.3	33.4	33.4	1193	1249	1221	2876	2957	2916	6223	6383	6303
N_2	34.1	34.7	34.4	1215	1270	1243	2919	3011	2965	6379	6542	6461
N_3	37.7	38.3	38.0	1273	1324	1298	3092	3175	3134	7330	7195	7262
N_4	35.7	36.0	35.8	1306	1367	1336	3821	3937	3879	8067	8300	8183
N_5	36.5	37.0	36.7	1311	1383	1347	4011	4125	4068	8367	8632	8499
S.Em.±	1.28	1.15	1.22	36	41	38	65	67	66	152	153	152
CD at5%	NS	NS	NS	NS	NS	NS	189	194	192	443	446	444
Interaction (I×N)												
I_1N_1	30.9	31.1	31.0	1154	1200	1177	2426	2519	2472	5896	6063	5980
I_1N_2	29.4	29.9	29.6	1160	1239	1200	2453	2554	2503	5985	6150	6068
I_1N_3	33.9	34.3	34.1	1169	1250	1209	2603	2681	2642	6149	6317	6233
I_1N_4	34.1	34.6	34.3	1272	1309	1290	3198	3270	3234	6967	7133	7050
I_1N_5	36.0	36.3	36.1	1271	1314	1292	3205	3275	3240	7000	7167	7083
I_2N_1	31.4	31.6	31.5	1180	1258	1219	3040	3113	3076	6272	6419	6346
I_2N_2	34.7	35.2	35.0	1181	1259	1220	3141	3237	3189	6485	6643	6564
I_2N_3	37.6	37.7	37.7	1326	1346	1336	3327	3409	3368	7667	7500	7583
I_2N_4	35.3	35.7	35.5	1322	1381	1352	3848	4078	3963	8233	8400	8317
I_2N_5	34.8	35.0	34.9	1323	1414	1368	4260	4347	4304	8967	9328	9148
I_3N_1	37.5	37.6	37.6	1243	1290	1267	3162	3238	3200	6500	6667	6583
I_3N_2	38.3	39.0	38.7	1304	1313	1309	3164	3244	3204	6667	6833	6750
I_3N_3	41.6	42.9	42.2	1324	1375	1350	3345	3437	3391	8176	7767	7971
I_3N_4	37.7	37.7	37.7	1323	1412	1367	4416	4462	4439	9000	9367	9183
I_3N_5	38.7	39.7	39.2	1339	1421	1380	4567	4751	4659	9133	9400	9267
S.Em.±	2.51	2.29	2.40	59	67	63	139	142	140	264	262	263
CD at5%	NS	NS	NS	NS	NS	NS	328	337	332	767	773	770

of plant. These results are in accordance with the findings of Mohanty *et al*. (2015) and Desai & Mudalagiriyappa (2022). The nutrients supplied by the SSNM target yield approach provide sufficient nutrients at all stages of growth due to split application. The nitrogen plays a major role in the cell growth and development, in turn helps for increased cell division and higher number of leaves and leaf area of the crop. The balanced application of nutrients at all growth stages with sufficient moisture regimes helped baby corn to achieve higher leaves and leaf area. These findings are in corroboration with results of Sadhana (2015), Hanumantappa (2016), Prajwalkumar (2017), Chaithra (2021) and Krishna Desai (2022).

The data on number of cobs per plant and weight of husked and dehusked cob are given in Table 4. There was significant difference in the number of cobs as affected by sensor based irrigation and nitrogen management.

IoT based drip irrigation at 50 per cent DASM recorded significantly higher cob per plant, husked and dehusked cob weight (2.8 cob plant^{-1}, 78.9 g plant^{-1} and 18.7 g plant^{-1}, respectively) and was on par with yellow SMI based drip irrigation (2.6 cob plant^{-1}, 75.5 g plant^{-1} and 17.9 g plant^{-1}, respectively). Surface irrigation recorded significantly lower values (2.2 cob plant^{-1}, 68.7 g plant^{-1} and 16.3 g plant^{-1}). Significantly higher cobsper plant, husked and dehusked cob weight were observed with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (3 cob plant^{-1}, 82.9 g plant^{-1} and 19.9 g plant^{-1}, respectively) and was on par with STCR based split application of N for targeted yield of 10 t ha^{-1} (2.9 cob plant^{-1}, 79.9 g plant^{-1} and 19 g plant^{-1}, respectively). Recommended dose of nitrogen recorded significantly lower values (2.0 cob plant^{-1}, 67.4 g plant^{-1} and 16.1 g plant^{-1}, respectively). IoT based drip irrigation at 50 per cent DASM along with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} recorded significantly higher cobs per plant, husked and dehusked cob weight (3.4 cob plant^{-1}, 90.4 g plant^{-1} and 21.9 g plant^{-1}, respectively) and it was statistically on par with IoT based drip irrigation at 50 per cent DASM along with application of fertilizers using STCR based split application of N for targeted yield of 10 t ha^{-1} (3.3 cob plant^{-1}, 88.3 g plant^{-1} and 21.1 g plant^{-1}, respectively) and yellow SMI based drip irrigation with SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (3.3 cob plant^{-1}, 85.5 g plant^{-1} and 20.9 g plant^{-1}, respectively). Surface irrigation with RDNrecorded significantly lower values (2.00 cob plant^{-1}, 64.9 g plant^{-1} and 15.7 g plant^{-1}, respectively).

The improvement in number of cobs, cob weight was due to additive effect of moisture and nutrients available to the crop during all the growth stages. The higher photosynthates contributing characteristics like plant height, number of leaves, leaf area, dry matter production have direct or indirect impact. The factors which have direct influence on the number of cobs are plant height, canopy coverage and leaf area. The fresh weight of cobs varied due to genetic potential of hybrid and differential application of irrigation and nutrients which resulted in higher cob length and cob girth resulted in higher fresh weight of cob (Afifi *et al*., 2011). The higher cob weight of baby corn was due to the positive influence exerted by moisture and higher dose of potassium in green seeker based SSNM application on the weight of cob, since it involved in the transportation of carbohydrates to the sink that is baby cobs (Roopashree, 2013 and Prajwalkumar, 2017). All these growth components could have been promoted by more quantity of nutrients made available by the treatments to baby corn crop. Timely irrigation and split dose of N fertilizer applications was the key to achieving higher cobs per plant, husked and dehusked cob weight. This was due to higher uptake of nutrients by the crop at all growth stages. (Trinh *et al*., 2008 and Biradar *et al*., 2013).

The data on yield of husked and dehusked baby corn cob are given in Table 5. There was significant difference in the yield as affected by sensor based irrigation and nitrogen management.

IoT based drip irrigation at 50 per cent DASM recorded significantly higher yield of husked and

TABLE 4

Number of cobs and cob weight of baby corn as influenced by sensor based irrigation and nitrogen management

Treatments	Cobs			Husked weight (g cob^{-1})			Dehusked weight (g cob^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
I_1	2.1	2.3	2.2	67.6	69.8	68.7	15.9	16.6	16.3
I_2	2.5	2.7	2.6	74.9	76.1	75.5	17.6	18.3	17.9
I_3	2.8	2.8	2.8	77.8	80.0	78.9	18.3	19.0	18.7
S.Em.±	0.07	0.06	0.07	1.68	1.58	1.63	0.34	0.35	0.35
CD at 5%	0.28	0.25	0.27	6.57	6.20	6.38	1.35	1.38	1.36
Sub plot (Nutrient)									
N_1	2.1	2.0	2.0	65.9	68.9	67.4	15.8	16.4	16.1
N_2	2.2	2.2	2.2	67.4	69.6	68.5	16.0	16.7	16.3
N_3	2.4	2.8	2.6	72.4	73.8	73.1	16.5	17.1	16.8
N_4	2.8	3.0	2.9	79.5	80.3	79.9	18.7	19.3	19.0
N_5	3.0	3.1	3.0	81.9	83.9	82.9	19.5	20.3	19.9
S.Em.±	0.05	0.07	0.06	1.12	1.24	1.18	0.42	0.44	0.43
CD at 5%	0.16	0.21	0.19	3.26	3.61	3.44	1.23	1.27	1.25
Interaction (I×N)									
I_1N_1	2.0	2.0	2.0	63.3	66.4	64.9	15.3	16.0	15.7
I_1N_2	2.1	2.1	2.1	64.7	67.2	65.9	15.6	16.2	15.9
I_1N_3	2.1	2.2	2.2	65.7	68.5	67.1	16.1	16.6	16.3
I_1N_4	2.2	2.5	2.4	71.9	72.9	72.4	16.2	16.9	16.6
I_1N_5	2.2	2.7	2.5	72.4	74.0	73.2	16.5	17.3	16.9
I_2N_1	2.1	2.0	2.1	66.2	69.5	67.8	16.2	17.0	16.6
I_2N_2	2.1	2.1	2.1	68.2	70.4	69.3	16.2	17.0	16.6
I_2N_3	2.2	3.1	2.6	76.5	76.3	76.4	16.0	16.7	16.3
I_2N_4	3.0	3.2	3.1	79.1	78.9	79.0	19.0	19.7	19.3
I_2N_5	3.3	3.2	3.3	84.6	85.5	85.0	20.5	21.3	20.9
I_3N_1	2.1	2.0	2.1	68.3	70.8	69.5	15.8	16.3	16.0
I_3N_2	2.4	2.3	2.3	69.4	71.3	70.4	16.3	16.8	16.6
I_3N_3	2.9	3.1	3.0	75.1	76.5	75.8	17.3	18.2	17.8
I_3N_4	3.3	3.3	3.3	87.6	89.1	88.3	20.8	21.3	21.1
I_3N_5	3.4	3.4	3.4	88.7	92.2	90.4	21.5	22.3	21.9
S.Em.±	0.11	0.13	0.12	2.41	2.49	2.45	0.74	0.76	0.75
CD at 5%	0.27	0.37	0.32	5.65	6.26	5.95	2.13	2.20	2.17

dehusked baby corn (182.4 and 71.7 q ha^{-1}, respectively) and was on par with yellow SMI based drip irrigation (175.3 and 67 q ha^{-1}, respectively). Significantly lower values were observed in surface irrigation (144.5 and 53 q ha^{-1}, respectively).

Significantly higher yield of husked and dehusked baby corn were observed with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (197.4 and 78.3 q ha^{-1}, respectively) and was on par with STCR based split

TABLE 5

Yield of baby corn as influenced by sensor based irrigation and nitrogen management

Treatments	Husked yield (q ha^{-1})			Dehusked yield (q ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled
Mainplot (Irrigation)						
I_1	143.6	145.5	144.5	52.2	53.9	53.0
I_2	175.1	175.5	175.3	66.5	67.5	67.0
I_3	181.1	183.8	182.4	71.2	72.2	71.7
S.Em.±	5.24	4.87	5.06	1.34	1.72	1.53
CD at5%	20.54	19.10	19.82	5.26	6.73	6.00
Subplot (Nutrient)						
N_1	140.2	140.4	140.2	49.4	50.2	49.8
N_2	143.3	144	143.7	51.7	52.9	52.3
N_3	162.8	165	163.9	62.2	64.2	63.2
N_4	190.8	193.1	191.9	75.7	76.3	76.0
N_5	195.8	199	197.4	77.6	79.0	78.3
S.Em.±	3.04	3.64	3.34	1.15	1.26	1.21
CD at5%	8.87	10.63	9.75	3.36	3.68	3.52
Interaction (I×N)						
I_1N_1	129.3	130.0	129.7	40.7	43.7	42.2
I_1N_2	131.9	133.3	132.6	43.3	45.0	44.2
I_1N_3	132.4	138.3	135.4	46.7	47.8	47.2
I_1N_4	160.8	160.9	160.9	64.3	65.0	64.7
I_1N_5	163.3	165.0	164.2	66.0	68.0	67.0
I_2N_1	144.3	142.9	143.6	50.0	50.0	50.0
I_2N_2	145.5	145.0	145.3	53.3	53.6	53.5
I_2N_3	177.7	175.0	176.4	68.3	70.8	69.6
I_2N_4	200.3	203.3	201.8	79.3	80.0	79.7
I_2N_5	207.7	211.3	209.5	81.7	82.9	82.3
I_3N_1	146.8	148.3	147.6	57.7	57.0	57.3
I_3N_2	152.5	153.7	153.1	58.3	60.0	59.2
I_3N_3	178.5	181.7	180.1	71.7	73.9	72.8
I_3N_4	211.3	215.0	213.1	83.3	84.0	83.7
I_3N_5	216.4	220.7	218.5	85.0	86.1	85.5
S.Em.±	7.04	7.46	7.25	2.23	2.60	2.42
CD at5%	15.36	18.41	16.88	5.82	6.38	6.10

application of N for targeted yield of 10 t ha^{-1} (191.9 and 76.0 q ha^{-1}, respectively). Significantly lower values were observed in recommended dose nitrogen (140.2 and 49.8 q ha^{-1}, respectively). IoT based drip irrigation at 50 per cent DASM along with application of fertilizer using SSNM based split application of NPK for targeted yield of 10 t ha^{-1} recorded significantly higher husked and dehusked baby corn yield (218.5 and 85.5 q ha^{-1}, respectively) and it was significantly on par with IoT based drip irrigation at

50 per cent DASM along with application of fertilizers using STCR based split application of N for targeted yield of 10 t ha^{-1} (213.1 and 83.7 q ha^{-1}, respectively) and yellow SMI based drip irrigation with SSNM based split application of NPK for targeted yield of 10 t ha^{-1} (209.5 and 82.3 q ha^{-1}, respectively). Surface irrigation with RDN recorded lower values (129.7 and 42.2 q ha^{-1}, respectively).

The higher baby corn yield is attributed to all growth parameters like plant height, leaf area, dry matter production, number of cobs, fresh cob weight of the plants. These attributes will be higher when adequate amount of irrigation and nutrients are supplied to the crop at all growth stages. Different levels of irrigation scheduling affects crop growth and uptake of nutrients added. In other words, irrigation played an imperative role in deciding the potential ability of baby corn to produce higher number of cobs per plant and husked and dehusked cob weight (Desai and Mudalagiriyappa, 2022). The husked and dehusked baby corn yield observed in sensor based automated drip irrigation at 50 per cent DASM, which helped to maintain adequate quantity of moisture throughout the crop growth period in turn it might have helped in good uptake of nutrients and favored on yield contributing factors. Increased cob weight and yield with SSNM approach was ascribed to the higher rate and balanced level of nutrient application (Jayaprakash *et al.*, 2006 and Umesh, 2008). Dry matter production at different growth stages of any crop is an important pre requisite for higher yields as it signifies photosynthetic ability of the crop (Asghar *et al.*, 2011).

The data pertaining to the water use efficiency is presented in Fig. 1. Irrigation water use efficiency (kg ha-mm^{-1}) differed significantly due to sensor based irrigation and nutrient management. Significantly higher Irrigation water use efficiency (26.7 kg ha-mm^{-1}) was observed in IoT based drip irrigation at 50 per cent DASM and was followed by Yellow SMI based drip irrigation (24.0 kg ha mm^{-1}). However, significantly lower IWUE recorded in surface irrigation (15 kg ha-mm^{-1}). Higher irrigation water use efficiency with drip irrigation system was attributed

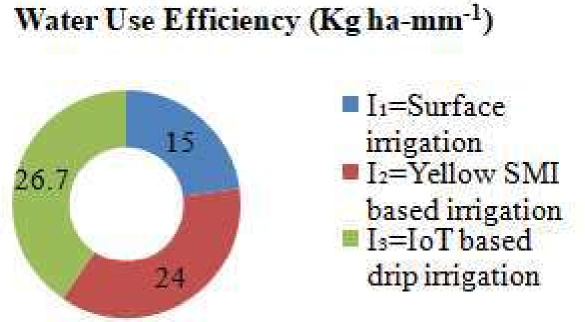

Fig. 1: Effect of irrigation methods on water use efficiency of different irrigation methods

to reduced water loss and efficient water use by the plants resulting in higher yield. Favourable effect of drip irrigation helps in maintaining of constant soil moisture potential (Shah and Das, 2012). Lower water use efficiency of surface irrigation was attributed to more evaporation and percolation loss of soil moisture due to more exposed wetting surface upon irrigation apart from reduced grain yield as compared to sensor based drip irrigation at 50 per cent DASM. Similar findings were reported by Barkunan *et al*. (2019) and Chaithra *et al*. (2021).

Framers can adopt smart farming technologies in scheduling the irrigation and can monitor their field from distant places. Artificial intelligence application in agriculture will bring new revolution in efficient irrigation management. The smart irrigation technologies will change the face of irrigation with increasing the irrigation efficiency and higher yield. Smart farming helps to increase in yield and input use efficiency. IoT based irrigation scheduling will help to save irrigation water with real time based water management. GreenSeeker based nitrogen management will help to save nitrogen in maize.

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