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Effect of GreenSeeker based nitrogen management and its interaction with water on growth and productivity of maize (*Zea mays* L.) under conservation agriculture

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ABSTRACT

A field experiment was conducted during kharif season of 2019 at research farm of ICAR–Indian Agricultural Research Institute, New Delhi, India, to study the effect of GreenSeeker(GS) based nitrogen management and its interaction with water on growth and productivity of maize (Zea mays L.) var. PMH-1 under conservation agriculture. The experiment was laid out in split-split plot design withtwo crop establishment techniques (CET) viz. conservation agriculture (CA) and conventional tillage (CT) in main plots three irrigation regime (IR) in sub-plotsirrigation at critical growth stages, irrigation at 25% depletion of available soil moisture (DASM) and irrigation at 50% DASM, and four levels of nitrogen (N) in sub-sub plots; no-N applied, 33% N as basal, 33% N at knee high stage and 34% N at silking stage, 50% basal + rest N as guided by Green Seeker (GS) and 75% as basal + rest N as guided by GS. The results showed that GS based N application outperformed over farmers fertilizer practices in terms of growth and productivity, and its interactionalso significantly differed with irrigation scheduling. The maximum value of grain yield (6.9 tha^{-1}), plant height at tasseling (173 cm) and harvest (235 cm), leaf area index at knee high stage (2.11) and silking (4.10), crop growth rate (8.4 and 9.2 gm^{-2}day^{-1}) at 0-30 and 30-60 days after sowing, respectively and NDVI (0.748), were recorded under75% as basal + rest N as guided by GS, over other practices and interaction effect with irrigation at 25% depletion of available soil moisture.

Key words: Conservation agriculture**,** availablesoil moisture**,** GreenSeeker, maize, nitrogen

INTRODUCTION

In India, maize (*Zea mays* L.) covers a large area of ~9.86 Mha, with a production and productivity of ~28.5 Mt and 2.89 t/ha, respectively (FAOSTAT, 2020). India's major maize producing states are Karnataka, Andhra Pradesh, Maharashtra, Uttar Pradesh and Bihar.Maize kernels are rich in essential nutrients, 10.0% protein, 4.3% fat, 74.4% carbohydrate, 1.3% minerals and 1.8% fiber, it's also contains small amounts of vitamins, calcium, magnesium, phosphorus and iron. As maize is a C_4 plant, it produces more dry matter per unit of input, letting it to be used in the production of biodiesel, it is essential in finding a solution of rising oil prices on an international market.Amino acids, proteins, nucleic acids, porphyrins, flavins, purines and pyrimidine nucleotides, flavin nucleotides, enzymes, coenzymes, and alkaloids all include nitrogen. Through photosynthesis, chlorophyll containing nitrogen fixes atmospheric CO_2.Nitrogen and water have been seen to regulate the variety of physiological and biological processes in plants. Under natural conditions, application of N fertilizer is prone to numerous losses, include denitrification, volatilization, leaching, and fixation with clay colloids. Nitrogen and water are two of the most important factors for crop production. Bijay-Singh *et al.* (2011)revealed that in India, high N use efficiency and productivity (Singh *et al.,* 2015) can be achieved by replacing ordinary fertilizer application with real time N management (Satish Kumar*et al.,* 2021). The Green seekercanopy sensor is an active optical sensor using red (650 ± 10 nm) and NIR (770 ± 15 nm) wavebands. To enhance maize production, optimizing the amount of nitrogen based on the volume of accessible water is essential. Hence, this experiment was conducted using maize as test crop.

MATERIALS AND METHODS

The experiment was conducted at research farm of ICAR-Indian Agricultural Research Institute, New Delhi, India (28°38'23"N, 77°09'27"E, and 228.61 MSL), during *Kharif season* 2019. This experiment was

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layout on a split-split plot design, having two crop establishment techniques (CET) *viz.* conservation and conventional tillage in the main plot,three irrigation treatments in sub-plots, and four nitrogen (N) in sub-sub plots. Soil of experimental farm is low in oxidizable–soil organic carbon (4.3 g kg^{-1}) alkaline $KMNO_4$ oxidizable–N (247 kg ha^{-1}), 0.5M $NaHCO_3$ extractable – P (14 kg ha^{-1}), and 1N NH_4OAc extractable–K (253 kg ha^{-1}). In CA, maize was sown using "Happy Seeder" and in CT seeds were sown using seed drill. Under CA, previous crop green gram residue applied @3.0 t/ha. Water and N were applied as per treatments *viz.*W_1 (irrigation at critical growth stages), W_2 (irrigation at 25% depletion of available soil moisture (DASM), W_3 (irrigation at 50% DASM), and 4 levels of nitrogen (N) in sub-sub plots; N_0 (no-N applied), N_1 (33% N as basal, 33% N at knee high stage and 34% N at silking stage), N_2 (50% basal + rest N guided by GS), and N_3 (75% as basal + rest N as guided by GS). Recommended dose of N i.e., 150 kg ha^{-1}.Maize cultivar "PMH-1" was sown with the onset of monsoon at 8th July. Plant height was recorded at tasseling and just before harvest on five randomly selected plants. Plant samples were kept in a hot air oven at 65^0 C for 48 hours to achieve a consistent dry weight for measurement of dry matter production. The leaf area per plant was measured by using leaf area meter which provided value in cm^2 and this was divided by theground area (1200 cm^2) of corresponding plant. Crop growth rate indicates the amount of dry matter produced from a given area under a given time, and expressed in (gm^{-2} land area/day). Net return was calculated by subtracting the cost of cultivation from gross return and then expressed in (□ ha^{-1}).The normalized difference vegetation index (NDVI) was measured manually using the Green Seeker(GS), which was held at a height of roughly 1 m above the plant canopy at 42 DAS. The sensor unit has self-contained radiance in both the red (656 ± 25 nm full width half magnitude (FWHM)) and near infrared (NIR; 774 ± 25 nm FWHM) bands.

$$\mathrm{NDVI} = \frac{\mathrm{NIRref} - \mathrm{REDref}}{\mathrm{NIRref} + \mathrm{REDref}}$$

Where, the fractions of NIR and red radiation reflected back from the sensed area. For treatment comparisons in the field experiment, the 'F-test' was used following the procedures of split-factorial design (Gomez and Gomez, 1984), and the least significant difference (LSD) was computed to determine statistically significant treatment differences.

RESULTS AND DISCUSSIONS

Plant height

The plant height at tasselling stage was found highest (173 cm) with 75% N application as basal+ rest as guided by GS, followed by 50% N application as basal+ rest as guided by GS (160 cm), and least in control (103 cm), (Table 1). The magnitude of increase in plant height with 75% N application as basal+ rest as guided by GS over N_2, N_1 and N_0-N were 6.7, 8.1 and 9.4%, respectively. Similarly, at harvest the maximum plant height was observed in 75% N application as basal+ rest as guided by GS (233 cm), followed by N_2 (218 cm), N_1 (215 cm) and control (143 cm), respectively (Table 1).The findings of Pooniya *et al.* (2015) showed that SSNM had a significant impact on plant height.Water application in differed treatments, significantly affected the plant height, but rate of increment in plant height was highest near to field capacity (FC), and diminishing rate was seen, after water depleted from FC in the rhizosphere.Application of water at 25 % DASM recorded maximum plant height (156 cm) at tasseling stage, which was 10 and 12 cm higher over irrigation at 50% DASM and at critical growth stages(Table 1). Irrigation at 25 % DASMhad a shorter interval between pre-determined water applications than the others, ensuring an adequate water and air proportion in the root zone throughout the season. This increased water and nutrient absorption, which are necessary for cell division, and cell elongation. A some what similar result was made by (Cakir, 2004).

Leaf area index

75%N application as basal + remainder as advised by GS had the higher leaf area index (LAI) at knee high stage (2.11), followed by 50% N application as basal + remainder as advised by GS (1.95), and lowest under control (1.41) (Table 1).When 75% N application as basal + remaining as indicated by GS was applied instead of N_2, N_1, and control, LAI rose by 8.2, 8.2, and 49.6%, respectively.Similarly, during the silking stage,75%N application as basal + remainder as advised by GS (4.10) had the higher LAI, followed by 50%N basal + remainder by GS (3.78), conventional practices (3.78), and

control (2.74).With 75 percent N was applied as a basal dosage, the plant developed efficiently in the formative stages, and the remaining dose was applied as needed to furnish an appropriate amount of N to the plant for absorption, translocation, and assimilation, as recommended by Green Seeker.The Pooniya *et al.* (2015) and Singh *et al.* (2015) both found that SSNM had a significant impact on growth parameters.The leaf area index was significantly affected by water application in various treatments, at knee high stage leaf area index recorded highestespecially when water was applied at a rate of 25% DASM, which was greater than irrigation at 50% DASM and at critical growth stages.Due to precision application of water based on depletion of available soil moisture resulted 7.7 and 19.9% increment of LAI at silking stage where irrigation applied at 25% DASM (3.91) over irrigation at critical growth stages (3.63) and minimum where irrigation appliedat 50% DASM (3.26), respectively.

Table 1: Effect of Green Seeker based nitrogen management and its interaction with water on growth and productivity of maize

Treatments	Plant height (cm)		Leaf area index		Crop growth rate ($gm^{-2}day^{-1}$)		Net returns (□ ha^{-1})	Grain yield ($t\ ha^{-1}$)	NDVI
	Tasseling	Harvest	Knee high stage	Silking stage	0-30 DAS	30-60 DAS			
Irrigation regime									
W_1	146	198	1.87	3.63	7.2	7.9	70688	5.43	0.72
W_2	156	213	2.01	3.91	7.9	8.4	86180	6.36	0.75
W_3	144	195	1.68	3.26	7.1	7.8	66579	5.18	0.73
SEm±	1.37	1.87	0.02	0.03	0.1	0.1	883	0.05	0.008
LSD(P≤0.05)	4.48	6.09	0.06	0.11	0.2	0.2	2878	0.17	0.023
N scheduling									
Control	103	141	1.41	2.74	5.1	5.0	41100	2.73	0.71
N_1	158	215	1.95	3.78	8.0	8.8	87286	6.36	0.73
N_2	160	218	1.95	3.78	8.2	9.0	91616	6.59	0.74
N_3	173	235	2.11	4.10	8.4	9.2	97927	6.94	0.75
SEm±	2.06	2.80	0.03	0.05	0.1	0.1	1497	0.08	0.008
LSD(P≤0.05)	5.92	8.04	0.07	0.15	0.3	0.3	4293	2.73	0.024

Note: W_1 (irrigation at critical growth stage), W_2 (irrigation at 25% depletion of available soil moisture DASM), W_3 (irrigation at 50% DASM), No (no-N applied), N_1 (33% N as basal, 33% N at knee high stage and 34% N at silking stage), N_2 (50%basal+rest N as guided by Green Seeker) and N_3 (75% as basal+rest N as guided by (GS)

Crop growth rate

Different N scheduling options also had significant influence on CGR, the highest CGR during 0-30 DAS under where 75%N application as basal + remainder as advised by GS (8.4 $gm^{-2}day^{-1}$), followed by 50%basal N + remainder as advised by GS (8.2 g m^{-2} day^{-1}) and lowest in N control treatments (5.1 g m^{-2} day^{-1}). Due to the scheduling of varied N applications, a nearly identical pattern of CGR was observed during 30-60 DAS.Because in 75% N application as basal + remainder as advised by GS, 75% N was applied as a basal dose, the plant grew quickly in the early stages, and the remaining dose was applied as needed to provide an appropriate amount of N to plant for absorption, translocation, and assimilation.The findings by Parihar *et al.* (2017), clearly indicated that SSNM had pronounced effect on the growth parameters of maize. Among irrigation regimes, the average CGR was (7.9, 7.2, 7.1 g m^{-2} day^{-1}, respectively) from 0-30 DAS at where irrigation at 25% DASM (7.9), followed by irrigation at critical growth stages and 50% DASM, respectively. Between 30-60 DAS, a similar pattern of CGR was found under varied IR, with 6.3 and 7% greater CGR obtained when moisture was given at 25% DASM over irrigation during critical growth stages and 50 percent DASM, respectively. Ensuring an adequate water and air proportion in the root zone throughout the season, resulted increased water and nutrient absorption, which are necessary for transpiration and photosynthesis.

Normalized difference vegetation index

Normalized difference vegetation index was measured manually using the GreenSeeker at 42 DAS, Various N scheduling choices had a significant impact on NDVI, highest value found

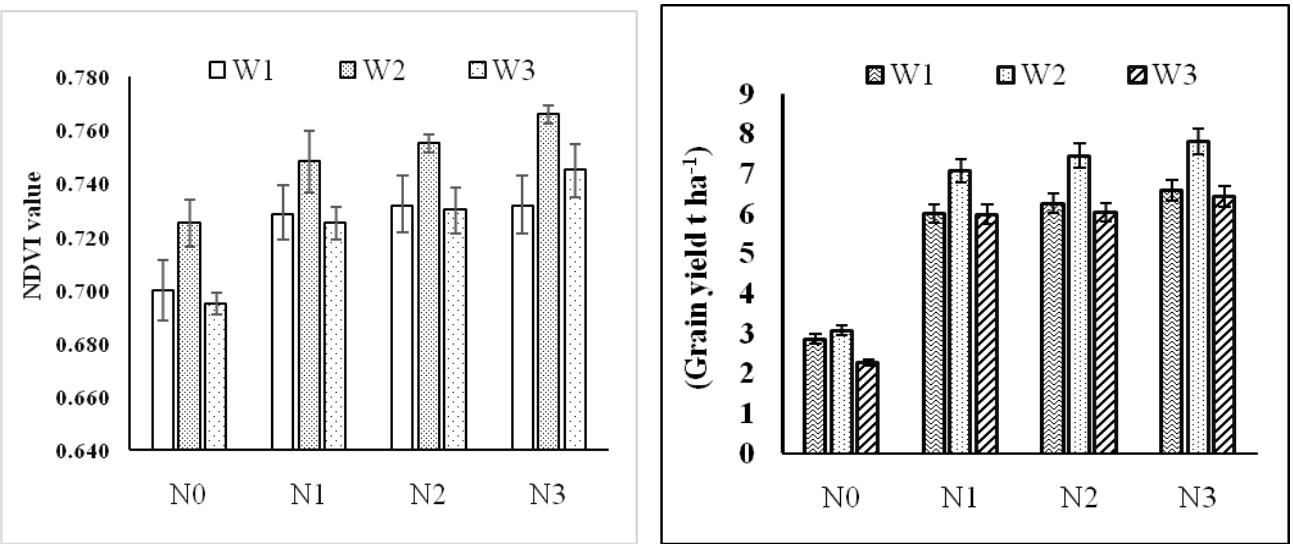

Figure1: Interaction effect of irrigation regime and nitrogen scheduling on NDVI and grain yield of maize

under where 75% N application as basal + remainder as advised by GS (Table 1). The proportion of light reflected in the visible light is defined by chlorophyll content in the cell, and the amount of light reflected in the near infrared region is defined by living vegetation or biomass. N content in plant drymatter and chlorophylls have a positive relationship. The leaf's ability to absorb blue and red light is proportional to its chlorophyll density. As a result, basal plants that received 75 percent N grew faster and produced more chlorophyll and biomass over other N scheduling. Increment in NDVI value due SSNM also reported by (Neha and Chandrashekar, 2018). Water application had a substantial impact on NDVI in various treatments, NDVI was maximum (0.75) when water was provided at a rate of 25% DASM, which was higher than irrigation at 50% DASM (0.73) and at critical growth stages (0.72).Irrigation at a rate of 25% DASM had a shorter gap between pre-determined water applications than the others, ensuring that the root zone received a proper water and air ratio throughout the season. This boosted N and water uptake, both of which are required for photosynthesis and chlorophyll formation.

Grain yield

Across the N scheduling options the highest mean grain yield under different irrigation regime was recorded with irrigation at 25% DASM (6.36 t ha^{-1}) which was 17.1 and 22.2%, higher over irrigation at critical growth stages (5.43 tha^{-1}) and W_3 (5.18 t ha^{-1}). Similarly, the maximum mean grain yield across the irrigation regime (6.94 tha^{-1}) was recorded under where 75% N application as basal + remainder as advised by GS, which was 5.3, 9.1 and 153% higher over where 50% N application as basal + remainder as advised by GS (6.59 tha^{-1}), conventional (6.36 t ha^{-1}) and lowest in control (2.74 tha^{-1}). The interaction between irrigation regime (IR) and N scheduling on grain yield of maize was found significant and the highest grain yield (7.81 tha^{-1}) was recorded with irrigation at Irrigation at 25% DASM × 75% N application as basal + rest as guided by GS, followed by irrigation at Irrigation at 25% DASM × 50% N as basal + rest as guided by GS (7.46 t ha^{-1}); however, the lowest maize grain yield (2.27 t ha^{-1}) was recorded under Irrigation at 50% DASM × N control (Figure 1). Here it is pertinent to mention that nutrient absorption in plants occur through mass flow. Optimum nutrient availability throughout the crop cycle and sufficient N supply during critical crop growth stages was assured under 25% DASM × 75% N application as basal + rest as guided by GS treatment. The higher soil available N, P and K content analyzed at harvest and higher mineral N content in upper profile. Increased maize grain yield owing to nutrient management changes was also noted by (Jain and Maliwal, 2022; Shekhawat *et al.,* 2021).

Net return

Among irrigation regimes, the highestnet return (86180 Rs ha^{-1}) where irrigation is applied

at 25% DASM, followed by (70688 Rs ha^{-1}) irrigation at critical growth stages and lowest (66579 Rs ha^{-1}) 50% DASM. On the other hand, the highest net return (97927 Rs ha^{-1}) was registered under 75% N application as basal + rest as guided by GS, followed by (91616 Rs ha^{-1}) 50% N application as basal + rest as guided by GS and least (41100 Rs ha^{-1}) in control. Like a result of applying 75 percent N as a basal + the remainder as directed by GS, the maximum grain and stover yields were observed, and less N was required as per real time N management, resulting in a more net return over conventional practices. N saving due to use of Green Seeker was also reported by (Bijay-Singh *et al.* 2011).

These results indicate that modified irrigation and GreenSeekerN scheduling as 75% basal + rest as guided by Green Seeker recorded higher plant height, leaf area index, crop growth rate, NDVI and grain yield of maize over conventional method. The interactive effect of 75% N as basal + rest as guided by Green Seekerat 42 days after sowing along with irrigation scheduling at 25% ASMD under CA based maize was found most productive in term of growth parameters and grain yield of maize.

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