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Influence of precision nutrient management on yield and yield components and dry matter partitioning in maize hybrids

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Abstract
A field experiment was conducted at Main Agriculture Research Station, Dharwad, during *kharif 2016* to evaluate influence of precision nutrient management on yield, yield components and dry matter partitioning in maize hybrids. The experiment consists of two maize hybrids (NK-6240 and S-6668) in main plot and eight sub plot treatments consisting of three precision nutrient techniques (PNM) site specific nutrient management (SSNM), soil test crop response (STCR) and nutrient expert (NE) to achieve target yield of 8 and 10 t ha^{-1}, recommended dose of fertilizer (RDF) and absolute control. The maize hybrid S-6668 recorded higher dry matter accumulation in cob at 90 DAS and at harvest, total dry matter production at 90 DAS, yield components, grain and stover yield (8.18 and 10.11 t ha^{-1}) than NK-6240. Among the sub plots, nutrient applied as per SSNM to achieve target yield of 10 t ha^{-1} showed higher dry matter partitioning at all the aforesaid stages, yield components, grain and stover yield (8.18 and 10.11 t ha^{-1}) than all other precision nutrient techniques, RDF and absolute control. Interactions shows that application of fertilizer based on SSNM to achieve target yield of 10 t ha^{-1} with maize hybrid S-6668 recorded higher dry matter accumulation in cob at 90 DAS and harvest (142.14 and 213.29 g) and total dry matter production at 90 DAS as well as yield and yield components except cob diameter and no. of kernels rows cob^{-1} were higher than all other treatment combinations.

Keywords: Economics, Maize, Precision nutrient management, Site specific nutrient management, Soil test crop response, Nutrient expert, target yield

Introduction

Maize is the second most important cereal crop in Asia, not only as a staple food, but also as a major component of feeds for the animal industry. It is one of the major cereal crops with wide adaptability to diverse agro-climatic condition around the globe and stands first with respect to production in the world. In India, it ranks third after rice and wheat. Due to its higher production potential and wider adoptability, maize being called “Queen of cereals” and it occupied an area of 182.06 and 8.55 million ha, produced 987 and 22.23 million tons with an average productivity of 5.4 and 2.6 tons ha^{-1} globally and in India, respectively (Anon., 2016) [1]. In 2004, the International Plant Nutrition Institute (IPNI) and its partners in Southeast Asia launched a regional initiative to increase the productivity and profitability of maize farming through improved crop and nutrient management (Witt and Pasuquin, 2007) [8].

Precision nutrient management is the key part of precision agriculture. The implementation of precision nutrient management can save fertilizer, increase food production and balance soil nutrients. Precision nutrient management is of great significance for black soil to reduce fertilizer inputs, increase maize production and improve maize quality. The key technologies of Precision nutrient management include the following three points. Firstly, it should be based on the spatial variation of soil nutrients to implement the accuracy of soil nutrient testing and crop nutrients diagnosing. Secondly, appropriate fertilization model should be determined to implement the precision of fertilizer amount. Thirdly, good fertilization machines should be selected to implement variable rate fertilization. Several approaches used for fertilizer recommendation in maize, like precision nutrient management through spatial variability assessment and variable rate technologies, Site Specific Nutrient Management (SSNM), Soil Test Crop Response (STCR), Nutrient Expert (NE) and Recommended Dose of Fertilizer etc. Among several soil test based fertilizer application techniques, site specific nutrient management (SSNM) and soil test crop response (STCR) are plant need based approaches with specific yield target. The SSNM and STCR approaches not only aim to reduce or increase fertilizer use and also cost effective tools for supplying crop nutrient as and when needed to achieve higher yield, besides this they also aims to increase system nutrient use efficiency, leading to more returns per unit of fertilizer invested (Shankar and Umesh, 2008) [12, 15]. Nutrient Expert is a decision support tool for nutrient management in hybrid maize based on SSNM principle and easy to use. It is developed by IPNI (International Plant Nutrition Institute) and CIMMYT, Mexico. It provides nutrient recommendation for an individual farmer field both in presence or absence of soil testing data and current INM practices, plant density, SSNM rates, source, splitting and profit analysis. This will help to increase yield and profit by target enabled fertilizer management strategy (Pompolino *et al*., 2012) [8].

Therefore, an investigation was carried out to analyze which Precision nutrient management techniques are the best for maize cultivation in rain fed conditions to attain maximum productivity and biomass production. Keeping above factors under consideration the present investigation was undertaken with the objectives to find out the best technique of precision nutrient management (PNM) for maize under rain fed conditions for better productivity and biomass production.

Materials and methods

A field experiment was conducted during *kharif* 2016 at Main Agriculture Research Station, University of Agricultural Sciences, Dharwad, situated on the at 15° 26′ N latitude and 75° 07′ East longitude and at an altitude of 678 m above mean sea level. The rainfall during cropping period was (568.22 mm) and mean maximum and minimum temperature were 30.84 and 14.53 ºC, respectively. The experiment was laid out in split plot design with two main plot and eight sub plot treatments. Main plot consists of two maize hybrids (NK-6240 and S-6668) and sub plot consists of eight precision nutrient management techniques *i.e.* site specific nutrient management (SSNM), soil test crop response (STCR) nutrient expert (NE) to achieve target yield of 8 and 10t ha^{-1}, recommended dose of fertilizer and absolute control. The soil of experimental site was medium black soil, neutral in pH (7.1), low in electrical conductivity (0.28 dS/m), medium in organic carbon (0.51%), low in available nitrogen (126 kg ha^{-1}), medium in phosphorus (44.50 kg ha^{-1}) and high in potassium (335.4 kg ha^{-1}). The quantity of nutrients required to achieve target yield was calculated by using the formulae for different techniques and is given in Table 1.

The nutrients required to achieve target yield through site specific nutrient management (SSNM) was calculated by using the formulae as given by (Biradar and Aladakatti, 2007) [2].

Table 1: Amount of Nutrients calculated and applied to achieve target yield in different treatments

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1-Target yield of 8 t ha^{-1} through SSNM	294	114	181
T_2-Target yield of 10 t ha^{-1} through SSNM	367	143	226
T_3-Target yield of 8 t ha^{-1} through STCR	264	146	68
T_4-Target yield of 10 t ha^{-1} through STCR	333	186	335
T_5-Target yield of 8 t ha^{-1} through NE	140	47	56
T_6-Target yield of 10 tha^{-1} through NE	150	64	98
T_7-RDF	100	50	25
T_8-Absolute control	0.00	0.00	0.00

NR = Nutrient uptake per quintal × T × ± per cent EFR

Where

NR = Nutrient required to achieve target yield in kg ha^{-1}
Uptake = Nutrient uptake by the crop per quintal of grain yield in the respective crop and location
T = Target yield (t ha^{-1})
EFR = Effective fertilizer rate (if the soil nutrient supply status is low, medium and high apply 20 per cent higher, same and 20 per cent lower than the estimated required quantity of nutrients, respectively).

Nutrient uptake by maize (3.06 kg N, 1.43 kg P_2O_5 and 2.82 kg K_2O) to produce a quintal of grain was worked out by referring previous 3 years data of International Plant Nutrition Institute (IPNI) project work on rain fed conditions at Dharwad and 2 years data of Jnanesh (2012) [6] on maize at the same location as suggested by IPNI was used to calculate the nutrient requirement to achieve target yields.

The STCR equation developed by All India Coordinated Research Project (AICRP) on Soil Test Crop Response (STCR), Bangalore (Anon., 2007) [1] was used in the study and are as follows

FN = 3.45 T - 0.093 SN ($KmnO_4$ - N)
FP_2O_5 = 2.00 T - 0.31 S P_2O_5 (Olsen's - P_2O_5)
FK_2O = 1.04 T - 0.046 S K_2O (NH_4OAC - K_2O)
Where,
FN= Nitrogen supplied through fertilizer in kg ha^{-1}
FP_2O_5 = Phosphorus supplied through fertilizer in kg ha^{-1}
FK_2O = Potassium supplied through fertilizer in kg ha^{-1}
T= Target yield
S N, S P_2O_5, S K_2O = Initial soil test value for available N, P_2O_5 and K_2O (kg ha^{-1}), respectively.

For nutrient expert based fertilizer recommendation ready reckoner software developed by International Plant Nutrition Institute (IPNI) 2014 was used.

The fertilizers were applied as per university recommendation, at basal half of nitrogen, entire dose of phosphorus and potassium in the form of 10:26:26, urea, MOP and SSP, respectively and they were applied as per the treatments. Remaining half of recommended nitrogen was top dressed at 30 DAS. Vermicompost was applied to the soil prior to sowing of crop to all the treatments as per the university recommendations including control plot at the rate 1.25 t ha^{-1}. Experimental plot was kept free from weeds throughout the crop growing period. Atrazine was applied as a pre-emergent herbicide at the rate of 1 kg a.i. ha^{-1} immediately after sowing. Two inter-cultivations were carried out at 30 DAS and 60 DAS by passing the bullock drawn hoe. One hand weeding was carried out at 30 DAS. For stem borer management, Carbofuron was applied to the leaf whorls' at the rate of 7.5 kg ha^{-1} after 20 days of sowing. All yield components were recorded at different growth stages of the crop. Grain and stover yield from net plot area was converted into per hectare basis. Economic returns were worked out based on the prevailing market prices of input, cost of fertilizers and outputs. Returns per rupee invested were worked out by considering net returns and cost of cultivation. The experimental data were analyzed statistically as per the procedures given by Gomez and Gomez (1984) [4].

Results and Discussion

Response of maize hybrids

Both the hybrids failed to show any significant differences with respect to dry matter accumulation in leaves and stem at all the growth stages. However S-6668 recorded higher dry matter accumulation in cob (113.71 and 170.41, g plant^{-1}, respectively) at 90 DAS and at harvest than NK-6240 (106.65 and 160.60 g plant^{-1}, respectively). Similarly, TDMP in both the hybrids did not show any significant difference at 30, 60 DAS and at harvest, whereas, at 90 DAS, S-6668 (215.60 g plant^{-1}) recorded higher TDMP than NK-6240 (204.07 g plant^{-1}) (Fig 1 and 2). The maize hybrid S-6668 produced significantly higher grain and stover yield (8.18 and 10.11 t ha^{-1}) which was significantly superior over NK-6240 (7.73 and 9.76 t ha^{-1}, resp.,). The increase in grain yield in S-6668 was to the extent of 5.8 per cent over NK-6240 (Table 3). The higher grain yield of S-6668 was mainly attributed to higher grain weight per cob over NK-6240. This may be due to genetic potential of S-6668 to utilize the resources properly, translocate photosynthates from source to sink and adaptability to agro-climatic conditions (Sampath *et al*., 2013) [13].

Harvest index: There was no significant difference between maize hybrids with respect to harvest index. SSNM with 10 t ha^{-1} recorded significantly higher harvest index (45.63%) as compared to other PNM techniques. However, all the treatments were on par with SSNM 10 t ha^{-1} except NE 8 t ha^{-1}, RDF and absolute control. The data on overall interaction did not show any significant difference between hybrids with same or different PNM techniques.

Table 2: Yield components of maize hybrids as influenced by different precision nutrient management (PNM) techniques

Treatments	Cob length (cm)	Cob diameter (cm)	No. of kernel rows cob^{-1}	No. of kernels rows^{-1}	No. of kernels cob^{-1}	Test weight (g)	Grain weight cob^{-1} (g)
Hybrids							
H$_1$ -NK-6240	16.66	14.43	13.15	31.31	415.06	34.58	178.93
H$_2$ -S6668	17.73	15.59	13.93	35.90	503.01	36.75	197.73
S. Em. ±	0.15	0.24	0.27	0.18	4.72	0.29	1.47
LSD (0.05)	0.94	NS	NS	1.07	28.71	1.74	8.95
PNM techniques							
T$_1$ – SSNM target yield 8 t ha^{-1}	17.77	15.50	13.53	36.33	492.09	37.08	210.65
T$_2$ – SSNM target yield 8 t ha^{-1}	18.91	16.61	14.94	38.00	569.14	40.10	234.40
T$_3$ – STCR target yield 8 t ha^{-1}	17.63	15.38	13.50	35.73	483.34	36.00	204.17
T$_4$ – STCR target yield 8 t/ha^{-}	18.40	16.24	14.02	36.88	518.22	38.88	227.61
T$_5$ – NE target yield 8 t ha^{-1}	17.47	15.11	13.37	35.10	469.33	35.42	196.25
T$_6$ – NE target yield 8 t ha^{-1}	18.04	16.05	13.80	36.50	504.51	37.25	224.57
T$_7$ – RDF	15.21	13.54	13.15	26.77	352.41	34.10	129.67
T$_8$ – Absolute control	14.11	11.66	12.02	23.50	283.23	26.50	79.33
S. Em. ±	0.17	0.34	0.33	0.38	7.91	0.26	2.01
LSD (0.05)	0.50	0.98	0.97	1.09	22.91	0.75	5.83
Interaction							
H$_1$T$_1$	17.24	14.83	13.33	34.00	453.17	35.67	197.67
H$_1$T$_2$	18.05	16.00	14.39	35.00	502.91	39.03	223.40
H$_1$T$_3$	17.09	14.63	13.27	33.13	440.25	35.00	193.02
H$_1$T$_4$	17.65	16.07	13.53	34.27	463.77	37.43	218.06
H$_1$T$_5$	17.01	14.26	13.20	32.47	427.87	34.33	182.96
H$_1$T$_6$	17.25	15.83	13.47	34.20	460.67	37.00	216.20
H$_1$T$_7$	15.08	12.71	12.87	25.67	330.43	33.20	121.83
H$_1$T$_8$	13.89	11.13	11.17	21.73	241.38	25.00	78.33
H$_2$T$_1$	18.31	16.17	13.73	38.67	531.01	38.50	223.63
H$_2$T$_2$	19.77	17.21	15.50	41.00	635.36	41.17	245.40
H$_2$T$_3$	18.16	16.13	13.73	38.33	526.43	37.00	215.32
H$_2$T$_4$	19.16	16.41	14.50	39.50	572.67	40.33	237.17
H$_2$T$_5$	17.93	15.96	13.53	37.73	510.79	36.50	209.53
H$_2$T$_6$	18.83	16.27	14.13	38.80	548.35	37.50	232.95
H$_2$T$_7$	15.34	14.37	13.43	27.87	374.40	35.00	137.50
H$_2$T$_8$	14.32	12.18	12.87	25.27	325.08	28.00	80.33
S. Em. ±	0.27	0.51	0.52	0.53	11.48	0.45	3.04
LSD (0.05)	0.79	NS	NS	1.53	33.25	1.29	8.82

NS-Non significant

T$_1$: 294:114:181 kg N, P_2O_5 and K_2O ha^{-1}
T$_2$: 367:143:226 kg N, P_2O_5 and K_2O kg ha^{-1}
T$_3$: 264:146:68 kg N, P_2O_5 and K_2O ha^{-1}
T$_4$: 333:186:89 kg N, P_2O_5 and K_2O ha^{-1}
T$_5$: 140:47:56 kg N, P_2O_5 and K_2O ha^{-1}
T$_6$: 150:64:98 kg N, P_2O_5 and K_2O ha^{-1}
T$_7$: 100:50:25 kg N, P_2O_5 and K_2O ha^{-1}
T$_8$: 0:0:0 kg N, P_2O_5 and K_2O ha^{-1}

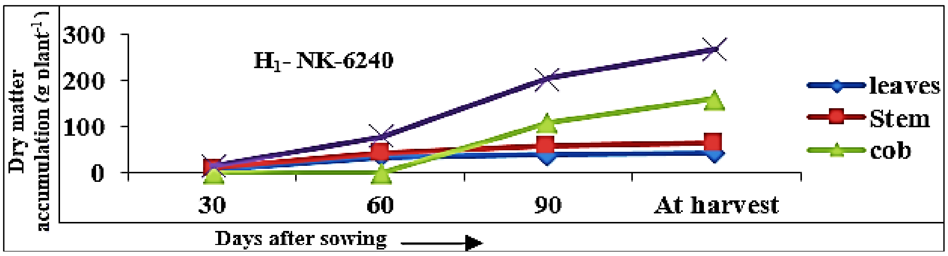

Fig 1: Dry matter accumulation influenced by hybrid NK-6240

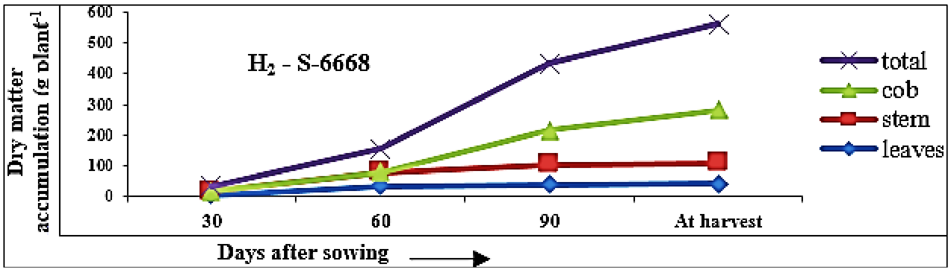

Fig 2: Dry matter accumulation influenced by hybrid S-6668

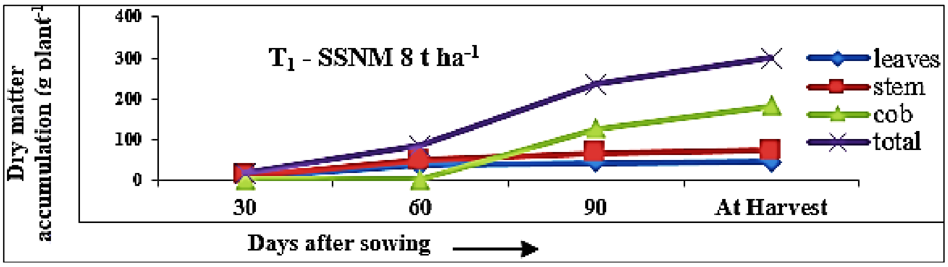

Fig 3: Dry matter accumulations as influenced by SSNM with 8 t ha^{-1}

Effect of different target yield based precision nutrient management techniques on dry matter

Significantly higher dry matter accumulation in leaves was recorded in SSNM 10 t ha^{-1} (6.28, 39.90, 46.05 and 48.63 g plant^{-1}, respectively at 30, 60, 90 DAS and at harvest) than other PNM techniques with different target yield (Fig. 4). However, STCR 10 t ha^{-1} (38.08, 45.11 and 47.17 g plant^{-1}, respectively) at 60, 90 DAS and at harvest was on par with SSNM 10 t ha^{-1} but only at 90 DAS, NE 10 t ha^{-1}(44.12 g plant^{-1}) was on par with SSNM 10 t ha^{-1}.(Fig. 6 and 8) Similarly, higher DMA in stem was recorded with SSNM 10 t ha^{-1} (12.33, 51.67, 71.17 and 77.74 g plant^{-1}, respectively) at all the aforesaid stages than other PNM techniques (Fig. 4). However, STCR 10 t ha^{-1}(50.22, 60.70 and 76.25 g plant^{-1}, respectively) was on par with SSNM 10 t ha^{-1} at 60, 90 DAS and at harvest, but at 90 DAS and at harvest, NE with 10 t ha^{-1} (49.65 and 74.83 g plant^{-1}, respectively) was on par with SSNM 10 t ha^{-1}. Significantly higher DMA in cobs was observed in SSNM 10 t ha^{-1} (139.57 and 208.76 g plant^{-1}) than other PNM techniques at 90 DAS and at harvest. However, STCR 10 t ha^{-1} (137.58 g plant^{-1}) was on par with SSNM 10 t ha^{-1} at 90 DAS. Higher total dry matter accumulation recorded with SSNM 10 t ha^{-1} (18.62, 91.57, 256.79 and 335.13 g plant^{-1}, respectively) at 30, 60, 90 DAS and at harvest than other PNM techniques (fig. 3 to 10). Application of 367 kg of N, 143 kg of P_2O_5 and 226 kg K_2O ha^{-1} through SSNM for target yield of 10 t ha^{-1} recorded higher grain yield than rest of the treatments, which was significantly superior over other techniques (STCR and NE). The increase in grain yield was 108 per cent over absolute control and 3.24, 7.43 and 35.13 per cent as compared to STCR, NE and RDF, respectively (Table 3). The higher grain and stover yield of maize was mainly due to better translocation of photosynthates from source to sink and higher growth attributing characters. The higher grain and stover yield of maize was mainly due to better translocation of photosynthates from source to sink and higher growth and yield attributing characters and higher dry matter production and its accumulation in different parts of plant and yield attributing characters like cob length, rows per cob, grains per rows, cob weight, grain yield per plant and test weight (Table 2). The above result clearly indicates the importance of application of nutrients through precision nutrient management techniques to achieve the required target yield of maize. The increase in grain yield of maize was due to the application of higher level of inorganic fertilizes. These results are in accordance with the findings obtained by Chetan (2015) [3].

Grain yield have direct and indirect impact. The factors which have direct influence on grain yield are the yield components namely grain weight per cob, test weight, cob length, number of rows per cob, number of kernels per cob (Table 2). However, dry matter production per plant and its accumulation into various plant parts particularly to cobs and intern to grains have a direct influence on grain yield through the yield components (Fig 3 – 10). The quantity of nutrients available to maize crop through this treatment was better than other techniques. This was evidenced though higher uptake of nutrients (data is not given); these findings are in confirming with the result of Umesh *et al*. (2014) [16].

In the present study yield attributing parameters namely cob length, number of kernel rows per cob, number of kernels per rows, number of kernels per cob, test weight and grain weight per cob differed significantly due to application of nutrient as per SSNM to achieve target yield of 10 t ha^{-1} (Table 2). These yield attributing parameters were significantly higher with application of SSNM 10 t ha^{-1} over other treatments. The results are in conformity with findings of Pagad (2014) [7] and Chetan (2015) [3].

The maximum total dry matter production and its partitioning in to plant parts in maize differed significantly due to different precision nutrient management techniques through target yield approach at all the stages of crop growth. Significant differences in total dry matter production at various phenological stages were mainly responsible for the differences observed in yield and yield components in crop. At 30, 60, 90 DAS and at harvest stages, the treatment with nutrients applied to achieve target yield of 10 t ha^{-1} through SSNM 10 t ha^{-1} recorded significantly higher total dry matter production than other PNM techniques and it was found to be on par with STCR 10 t ha^{-1} at 60 and 90 DAS (Fig. 4 and 6). The increase in total dry matter production to the extent of 18.44, 50.53, 88.35 and 57.63 at 30, 60, and 90 DAS and at harvest stage than RDF (Fig. 4 and 9). Lower dry matter production was observed in absolute control (Fig 10).

The significant improvement in dry matter production probably resulted from better nutrition and higher availability of N, P_2O_5 and K_2O which resulted in better uptake of nutrients by the crop. Therefore, better availability and uptake of nutrients is assigned as the reason behind the significant increase in dry matter production. Significant increase in dry matter production with higher nutrient level was also reported by Shridhara *et al.* (2014) [11]. The improved photosynthetic capacity was associated with higher N, P_2O_5 and K_2O nutrition as indicated by better uptake of major nutrients. All the three elements (N, P_2O_5 and K_2O) were critically involved in photosynthesis and dry matter production (Tisdale *et al.* 1986) [14].

Table 3: Grain yield, stover yield and harvest index of maize hybrids as influenced by different precision nutrient management (PNM) techniques

Treatments	Grain yield (t ha^{-1})	Stover Yield (t ha^{-1})	Harvest index
Hybrids (H)			
H_1-NK6240	7.73	9.76	43.86
H_2-S6668	8.18	10.11	44.47
S. Em. ±	0.07	0.05	0.30
LSD (0.05)	0.43	0.29	NS
PNM techniques			
T_1 - SSNM target yield 8 t ha^{-1}	8.41	10.46	44.52
T_2 - SSNM target yield 10 t ha^{-1}	9.49	11.30	45.63
T_3 - STCR target yield 8 t ha^{-1}	8.18	10.26	44.13
T_4 - STCR target yield 10 t ha^{-1}	9.19	11.04	45.41
T_5 - NE target yield 8 t ha^{-1}	7.95	10.14	43.77
T_6 - NE target yield 10 t q ha^{-1}	8.83	10.75	45.11
T_7 - RDF	7.02	9.07	43.64
T_8 - Absolute control	4.56	6.53	41.16
S. Em. ±	0.09	0.06	0.36
LSD (0.05)	0.27	0.17	1.03
Interaction (H X T)			
H_1T_1	7.98	10.15	43.98
H_1T_2	9.10	11.01	45.24
H_1T_3	7.97	10.10	43.60
H_1T_4	8.85	10.81	45.00
H_1T_5	7.83	9.98	43.57
H_1T_6	8.63	10.65	44.76
H_1T_7	6.97	8.96	43.77
H_1T_8	4.49	6.49	40.92
H_2T_1	8.83	10.77	45.06
H_2T_2	9.88	11.59	46.02
H_2T_3	8.40	10.41	44.66
H_2T_4	9.53	11.27	45.81
H_2T_5	8.08	10.30	43.96
H_2T_6	9.03	10.84	45.46
H_2T_7	7.06	9.17	43.50
H_2T_8	4.63	6.57	41.29
S. Em. ±	0.14	0.09	0.56
LSD (0.05)	0.41	0.27	NS

NS-Non significant

T_1: 294:114:181 kg N, P_2O_5 and K_2O ha^{-1}
T_2: 367:143:226 kg N, P_2O_5 and K_2O kg ha^{-1}
T_3: 264:146:68 kg N, P_2O_5 and K_2O ha^{-1}
T_4: 333:186:89 kg N, P_2O_5 and K_2O ha^{-1}
T_5: 140:47:56 kg N, P_2O_5 and K_2O ha^{-1}
T_6: 150:64:98 kg N, P_2O_5 and K_2O ha^{-1}
T_7: 100:50:25 kg N, P_2O_5 and K_2O ha^{-1}
T_8: 0:0:0 kg N, P_2O_5 and K_2O ha^{-}

Table 4: Interaction of maize hybrids and different precision nutrient management (PNM) techniques on total dry matter and its accumulation in different parts

Treatments	total dry matter and Dry matter accumulation in different parts (g plant -1)													
	At 30 DAS			At 60 DAS			At 90 DAS				At harvest stage			
H_1- Hybrid NK 6240 x PNM techniques	**Leaves**	**Stem**	**Total**	**Leaves**	**Stem**	**Total**	**Leaves**	**Stem**	**Cobs**	**Total**	**Leaves**	**Stem**	**Cobs**	**Total**
T_1 -SSNM TY 8 t ha^{-1}	5.3	10.7	16.0	35.9	46.8	82.8	41.9	65.2	120.0	227.2	43.7	72.1	170.3	286.2
T_2 -SSNM TY 10 t ha^{-1}	5.7	11.3	17.0	39.4	50.8	90.2	45.1	70.0	137.0	252.1	48.2	76.5	204.3	329.0
T_3 - STCR TY 8 t ha^{-1}	5.2	10.7	15.9	34.8	46.3	81.1	41.8	64.0	117.7	223.6	42.5	71.0	169.0	282.5
T_4 - STCR 10 t ha^{-1}	5.4	11.1	16.5	37.6	49.2	86.8	44.2	68.3	134.4	247.0	46.1	75.4	197.1	318.7
T_5 - NE TY 8 t ha^{-1}	5.2	10.6	15.8	33.1	45.1	78.2	40.1	62.9	109.0	212.0	41.7	70.1	157.4	269.2
T_6 - NE 10 t ha^{-1}	5.3	11.0	16.3	36.6	48.5	85.0	43.1	67.0	123.3	233.4	45.3	73.7	180.1	299.1
T_7 - RDF	5.1	10.5	15.6	27.3	32.6	59.8	31.1	39.0	64.8	134.9	35.5	49.3	125.1	209.9
T_8 - Absolute control	4.4	10.2	14.6	23.1	25.6	48.7	25.7	29.8	47.0	102.4	29.4	33.8	81.5	144.8
Mean of NK6240	5.2	10.8	16.0	33.5	43.1	76.6	39.1	58.3	106.7	204.1	41.6	65.3	160.6	267.4
T_1 -SSNM TY 8 t ha^{-1}	5.4	11.1	16.5	36.1	49.8	85.9	44.2	69.7	131.0	244.9	45.1	74.7	191.1	311.0

T_2 -SSNM TY 10 t ha^{-1}	6.9	13.3	20.3	40.4	52.5	92.9	47.0	72.3	142.1	261.5	49.1	78.9	213.2	341.2
T_3 - STCR TY 8 t ha^{-1}	5.3	11.0	16.3	35.0	48.7	83.7	43.2	68.5	127.3	239.0	43.4	73.2	182.0	298.7
T_4 - STCR 10 t ha^{-1}	6.1	11.6	17.7	38.5	51.2	89.8	46.0	71.1	140.7	257.8	48.2	77.1	208.5	333.8
T_5 - NE TY 8 t ha^{-1}	5.3	10.8	16.1	34.0	47.3	81.3	41.3	67.1	122.3	230.7	42.2	71.4	165.4	279.0
T_6 - NE 10 t ha^{-1}	5.5	11.3	16.8	37.4	50.8	88.2	45.1	70.0	133.7	248.8	47.1	76.0	191.7	314.8
T_7 - RDF	5.2	10.6	15.8	28.7	33.1	61.8	32.2	41.0	65.3	137.8	36.6	50.1	128.6	215.3
T_8 - Absolute control	4.6	10.3	14.9	24.1	27.0	51.0	26.3	30.8	47.2	104.3	30.7	35.8	82.8	149.3
Mean of S -6668	5.5	11.3	16.8	34.3	45.1	79.3	40.6	61.3	113.7	215.6	42.8	67.2	170.4	280.4
S.Em. ±	0.25	0.31	0.49	1.33	1.11	2.8	1.25	1.6	2.38	2.70	1.36	2.42	2.64	4.00
LSD	NS	NS	NS	NS	NS	NS	NS	NS	6.90	7.81	NS	NS	7.64	NS

NS-Non significant

T_1: 294:114:181 kg N, P_2O_5 and K_2O ha^{-1}
T_2: 367:143:226 kg N, P_2O_5 and K_2O kg ha^{-1}
T_3: 264:146:68 kg N, P_2O_5 and K_2O ha^{-1}
T_4: 333:186:89 kg N, P_2O_5 and K_2O ha^{-1}
T_5: 140:47:56 kg N, P_2O_5 and K_2O ha^{-1}
T_6: 150:64:98 kg N, P_2O_5 and K_2O ha^{-1}
T_7: 100:50:25 kg N, P_2O_5 and K_2O ha^{-1}
T_8: 0:0:0 kg N, P_2O_5 and K_2O ha^{-1}

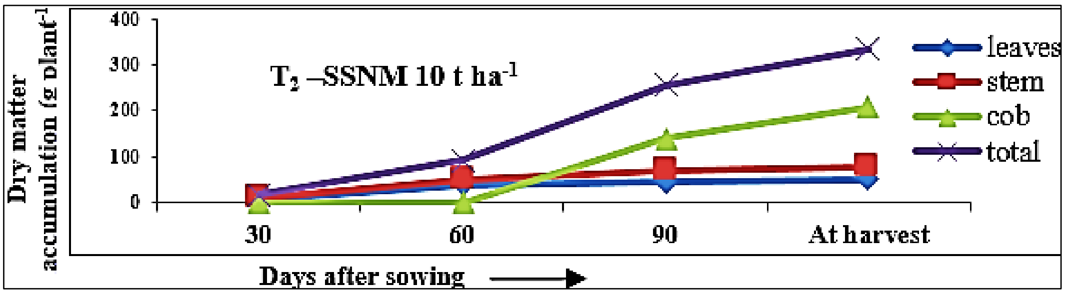

Fig 4: Dry matter accumulations as influenced by SSNM with 10 t ha^{-1}

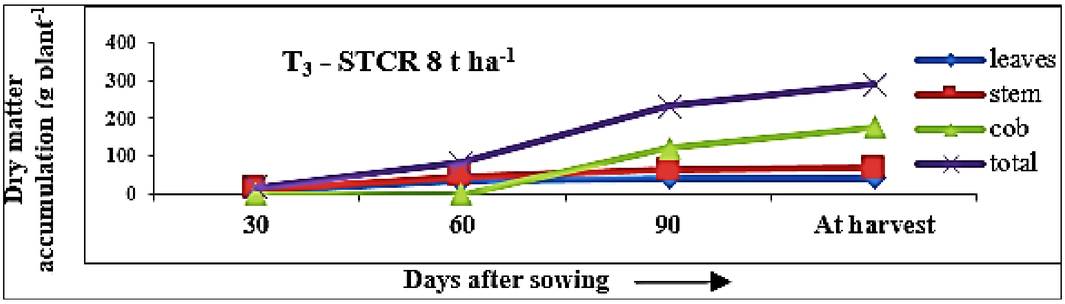

Fig 5: Dry matter accumulations as influenced by STCR with 8 t ha^{-1}

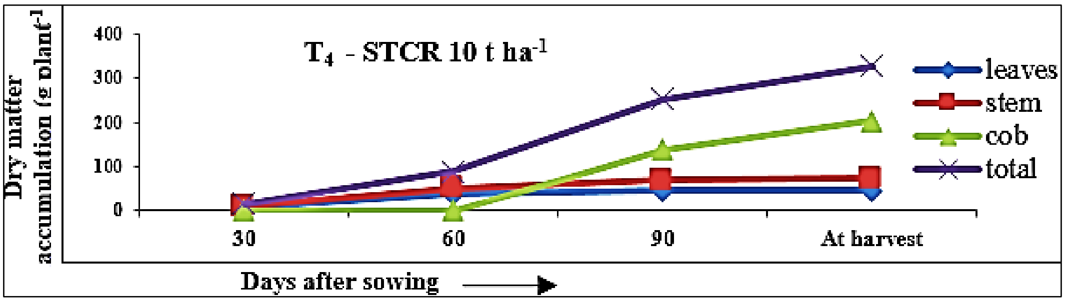

Fig 6: Dry matter accumulations as influenced by STCR with 10 t ha^{-1}

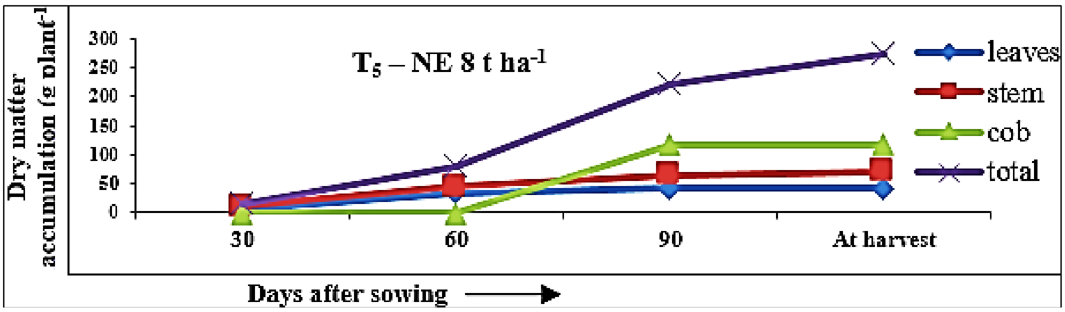

Fig 7: Dry matter accumulations as influenced by NE with 8 t ha^{-1}

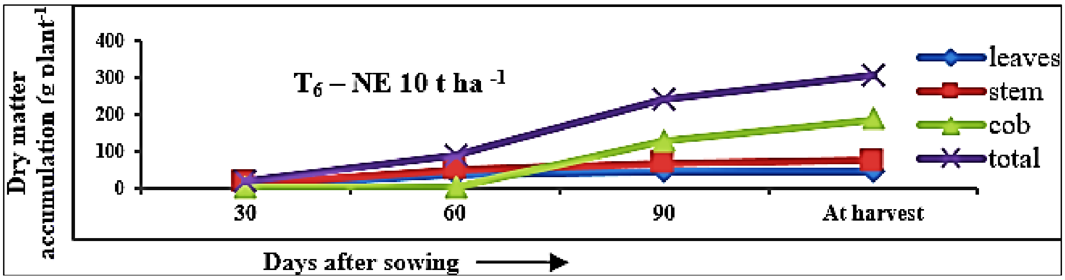

Fig 8: Dry matter accumulations as influenced by NE with 10 t ha-1

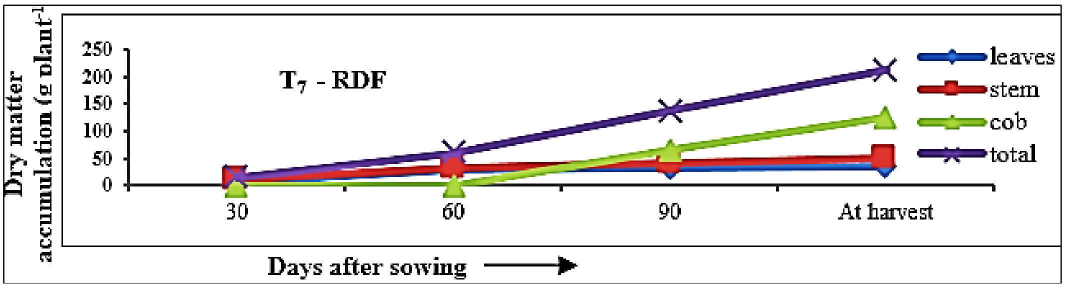

Fig 9: Dry matter accumulations as influenced by RDF

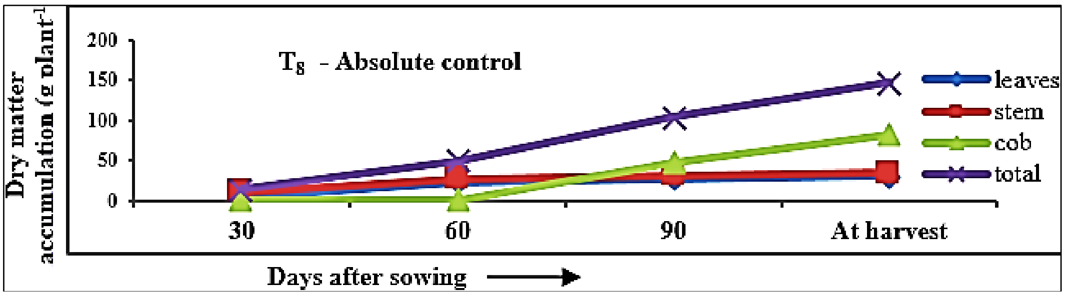

Fig 10: Dry matter accumulations as influenced by absolute control

Interaction effect of maize hybrids and precision nutrient management techniques

The data on interactions of dry matter accumulations (DMA) were found to be non-significant at 30, 60 and 90 DAS and at harvest in leaves and stem but in cob at 90 DAS and at harvest stage, S-6668 with SSNM 10 t ha^{-1} (142.14 and 208.76 g plant^{-1}, respectively) recorded significantly higher DMA in cobs over rest of the treatment combinations (fig. However S-6668 with STCR 10 t ha^{-1} (140.73 and 208.47 g plant^{-1}, respectively) was on par with S-6668 with SSNM 10 t ha^{-1} at 90 DAS and at harvest. Similarly higher total dry matter production recorded in S-6668 with SSNM 10 t ha^{-1} (261.48 g plant^{-1}) than other treatment combinations at 90 DAS. However, STCR 10 t ha^{-1} (257.82 g plant^{-1}) was on par with SSNM 10 t ha^{-1}. Significantly higher grain yield (9.87 t ha^{-1}) was obtained in S-6668 with SSNM 10 t ha^{-1} than other treatment combinations and it was on par with STCR 10 t ha^{-1}. Lower grain yield was recorded with treatment combination of NK-6240 with absolute control (4.49 t ha^{-1}) (Table 3). The increase in grain and stover yield was to the extent of 39.80 and 26.31 per cent higher in S-6668 with SSNM 10 t ha^{-1} over RDF. The superiority of economical yield in treatment combination of S-6668 with SSNM 10 t ha^{-1} than other treatment combinations might be due to better translocation of photosynthates from source to sink and higher growth attributing characters and yield attributing characters like cob length, number of kernel rows per cob, number of kernels per rows, number of kernels per cob, test weight and grain weight per cob (Table 2). Higher grain yield in SSNM with target yield of 10 t ha^{-1} was ascribed to higher rate of fertilizer and also balanced nutrient application. This was evidenced through the findings of Umesh (2008) [12, 15]. The increase in grain and stover yield was (39.80 and 26.31 per cent, respectively) in S-6668 with SSNM 10 t ha^{-1} over RDF. The superiority of yield components in treatment combination of S-6668 with SSNM 10 t ha^{-1} than other treatment combinations was due to higher dry mater production and its translocation to the reproductive parts led to higher yield over other treatment combinations., The higher dry matter production was due to better leaf area and higher growth parameters.

Prerequisite for getting higher yield in any crop is determined by total dry matter production and it's partitioning in to various plant parts. Total dry matter production, is the reflection of biological efficiency of cultivar and the nutritional level supplied. Higher dry matter accumulation in leaves which are photosythetically active is responsible for overall growth which has positive effect on higher DMA in leaves resulted in higher leaf area index and yield.

In conclusion, the present study showed that the performance of maize hybrid S-6668 better than NK-6240. The target yield of 10 t ha^{-1} in maize can be achieved (9.87 t ha^{-1}) through site specific nutrient management techniques with S-6668 than other PNM techniques.

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