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RESEARCH ARTICLE

ASSESSMENT OF PRECISION NUTRIENT MANAGEMENT PRACTICES ON CROP GROWTH, PRODUCTIVITY, AND PROFITABILITY OF MAIZE GROWN DURING WINTER IN CENTRAL TERAI, NEPAL

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ABSTRACT

To assess the effect of precision nutrient management practices on the growth, productivity, and profitability of different maize cultivars grown during winter, a field experiment was accomplished at Khairahani, Chitwan, during 2018/19. The field experiment was laid out in split-plot design with three replications for two maize cultivars as main-plot treatments (V_1-Rampur Composite and V_2-Rampur Hybrid-6) and four precision nutrient management practices as sub-plot treatments (T_1-Blanket recommendation (60:30:30 kg NPK ha^{-1}), T_2-SSNM based Nutrient Expert-Maize model recommended dose (110:27:33 kg NPK ha^{-1}), T_3-Farmers' fertilizer practices (82.5:34.5:15 kg NPK ha^{-1}), T_4-LCC based Nitrogen and farmers' practice-based P and K). The experimental finding indicated that the overall performance of the Rampur Hybrid-6 cultivar was superior to Rampur Composite in terms of yield and yield attributes. SSNM-based NE-Maize model was superior to other nutrient management practices on growth attributes viz. plant height, leaf area index and crop growth rate, yield attributing characters viz. total number of kernels cob^{-1}, number of rows cob$^{-1,}$ and kernel yield. SSNM-based NE- Maize model recorded the best performance with the highest BC ratio (2.47) followed by LCC-based Nitrogen over the farmer's fertilizer practice-based P and K (2.42).

KEYWORDS

Central Terai, Crop growth, Maize cultivars during winter, Precision nutrient management, Productivity, Profitability

1. INTRODUCTION

Maize (*Zea mays* L.) is globally known as the 'queen of cereals' because of its highest genetic yield potential among the cereals. It contains approximately 72% starch, 10% protein, and 4% fat and can supply energy of 365 Kcal/100 g (Ranum et al., 2014). In Nepal, maize is the second most important cereal crop, which occupies 29.90% of the total cultivated area and shares about 6.88% of the total Agricultural Domestic Product of the country (MOALD, 2020). Maize is currently grown in 9,56,447 ha of land with the production of 27,13,635 tons and an average yield of 2.83 t ha^{-1} in Nepal, which is comparatively low compared to the global yield standard of 12 t ha^{-1} (MOALD, 2020; MOAC/ABPSD, 2003). Appropriate crop management technologies and approaches are needed to narrow the gaps, conserve agro-biodiversity and increase production, that help in food self-sufficiency (Bhusal et al., 2021).

Site-specific nutrient management (SSNM) is an approach for "feeding" crops with nutrients as and when needed and thus can improve nutrient use efficiency, crop yield, and farmers' income. It advocates the optimal use of existing indigenous nutrient sources and timely application of fertilizers at optimal rates (Witt et al., 2007). The plant-based approach of SSNM, for instance, the use of Leaf Color Chart (LCC), enables farmers to apply fertilizer N in several doses to ensure the supply of sufficient N is synchronized with the crop need for N at critical growth stages (Satyanarayana et al., 2014). Nutrient Expert® - Maize (NE), a computer-based decision support tool, enables the maize growing farmers of India to implement SSNM for their individual plots, utilizing the information given by local experts to suggest meaningful yield for that location and formulate a fertilizer management strategy (Satyanarayana et al., 2014).

In spite of the large research efforts to increase the maize yield, the yield level in the farmer's field is far below than the varietal yield potential. Among the various factors responsible for lower production of maize, the choice of proper cultivars suited to the agro-ecozone and various agronomic management factors, including poor nutrient management practices, are the major agendas (Dahal et al., 2018; Rajbhandari et al., 2014). Most farmers use a high amount of chemical fertilizer haphazardly since there is little information available on NPK requirements for hybrid and improved maize production in Nepal. Also, fertilizer recommendations by the Government of Nepal and other reliable agencies and research stations are based on blanket recommendations for a wide range of agro-ecological zones without considering the variability of soil nutrient status in those regions. Therefore, the present research eventually helps to verify the effect of precision nutrient management practices on the growth, productivity, and profitability of promising maize cultivars grown during winter in central Terai in Nepal.

2. MATERIAL AND METHODS

2.1 Field Experimentation

A field experiment was conducted during the winter season of 2018/19 at Khairahani, Chitwan in inner terai with the financial support of the

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University Grant Commission to evaluate the effect of different nutrient management practices on growth, yield, and yield attributes of promising maize cultivars. Rice-Wheat has been the main cropping pattern in this area for the last five years. However, winter maize is considered a suitable crop during winter. The site is at an altitude of 168 meters above mean sea level. Geographically, it is located at 27^0 37' North latitude and 84^0 03' East longitudes. The soil type is sandy loam and climatically humid sub-tropical with an average annual rainfall of 2000 mm (mainly during mid to late summer). The meteorological data of a cropping season was obtained from the nearest meteorological station at khairahani. A Survey of the experimental site, soil sampling, and initial fertility evaluation was done.

The soil of the study site was collected from five different depths viz 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, and 80-100 cm. Then the composite sample is prepared by taking soil from different depths. Its mechanical, physical, and chemical properties were analyzed in the soil laboratory of Agriculture Technology Center (ATC), Pulchowk, Lalitpur. Data showed that during experimentation, the crop received a total rainfall of 210.14 mm from November 2018 to April 2019. Therefore the amount of rainfall is conducive for satisfactory growth of maize. The maximum temperature varied between 17.2°C and 36.03°C, while the minimum temperature ranged between 4.97°C and 22.95°C during the cropping period, as shown in figure 1. Average weather records during the crop growth period (10 days interval) are presented below:

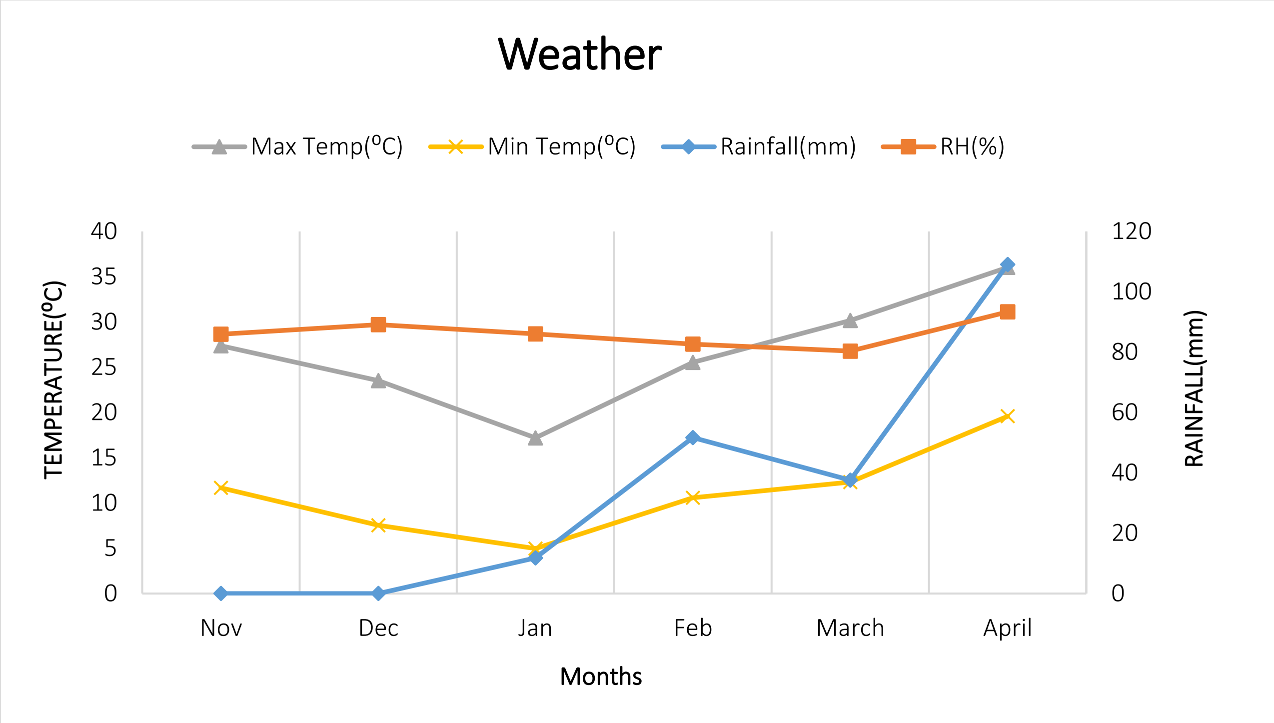

Figure 1: Average weather record during a research period at Khairahani-5, Chitwan in 2018/19 (Department of Hydrology and Meteorology)

The field experiment was laid out in a split-plot design with two maize cultivars as main plot treatments (Rampur Composite and Rampur Hybrid-6). The four different nutrient management practices as subplot treatments (T1-Blanket recommendation (60:30:30 kg NPK ha-1), T2-SSNM based Nutrient Expert Maize model recommended dose (110:27:33 kg NPK ha-1), T3-Farmers' fertilizer practices (82.5:34.5:15 kg NPK ha-1), T4-LCC based Nitrogen but farmers' practice-based P and K) and replicated thrice. The total area required for the field to the layout was 585 m^2. The space between the treatments was 0.5 m, and the distance between the blocks was 1 m. Each plot was designed to maintain its 3 m width and 6 m length. Each plot contained 24 rows and five columns in an 18 m^2 area. Crop geometry was 60 cm x 25 cm; row to row and plant to plant distance, respectively. This design has 120 plants per plot and 2880 plants in the whole field.

To determine NPK dose for T2-SSNM based Nutrient Expert Maize model, a survey was conducted with ten farmers and agro vet persons of Khairahani with the standard format of the questionnaire. Then the entry of obtained data was done to the NE software, and the fertilizer dose was calculated for that particular location. Similarly, to find out the NPK dose for T3-Farmers' fertilizer practices, another survey was conducted with 15 farmers of Khairahani, Chitwan. Then the practices and nutrient dose adopted by a majority of farmers were used in the research plot.

For T4-LCC based Nitrogen but farmers' practice-based P and K), the basal dose was applied @ 20kg N ha-1, and then the LCC meter was used for N supplement -30 days after sowing (DAS) and in the interval of 15 days for four times @ 15kg N ha-1 each time. The subsequent N applications were carried out by matching the color of the youngest fully expanded top leaf of ten randomly selected maize plants from each plot at 15 days intervals, starting from 30 days after sowing of maize till the initiation of silking. If the greenness of 6 or more out of ten leaves is less than the LCC threshold, then the fertilizer was applied as per the recommended dose. Whereas the greenness of 5 or more out of ten leaves exceeds the LCC threshold, no N was applied. During analysis color of the leaf with LCC under the shade of the body was matched visually with LCC and disease/insect-free leaves of a normal crop. Matching of the leaf was discontinued, and no further N was applied after the initiation of silking.

2.2 Observations Taken

Plant height was measured from the ground level to the topmost visible due lap of five randomly selected plants from each plot at 30 DAS, 45 DAS, 60 DAS, 75 DAS, 90 DAS, 105 DAS, and 120 DAS. The number of leaf per plant were also counted from 5 randomly selected plants from each plot from 30 DAS to 120 DAS at 15 days interval. The topmost, middle and lower leaves from each plant were selected, and leaf length and diameter from 3 positions were taken. Then, leaf area index was calculated as:

$$\mathrm{LAI} = \frac{\text{Leaf area } (\mathrm{cm}^2)}{\text{Land area } (\mathrm{cm}^2)}$$

To measure dry matter accumulation, one plant during each observation from the second row of each plot was uprooted, and above ground, the portion was packed in the envelope and was dried in a hot oven for 48 hours at a temperature of 72 °C. Then, the dry weight of the whole plant was taken and expressed as t ha^{-1}.

Total numbers of ears harvested from the net harvested area were recorded as harvested ears $plot^{-1}$, and it is converted in harvested ears ha^{-1}. The ear length and sterile length of five randomly selected ears from each plot were taken by using jute string from the base of the ear to the top, which is then measured in scale. The circumference of the ears was taken from the base, middle and upper portion of the ear with the help of a jute string which was then measured in scale. Five randomly selected ears from each plot were shelled, and all the kernels were counted and reported as a number of kernels ear^{-1}. The number of rows ear^{-1} was counted from those five randomly selected ears from each plot and then averaged. Similarly, the number of kernels row^{-1} was counted and then averaged. One thousand shelled maize grains from each plot were randomly taken, weighed, and recorded as test weight and expressed in gram (g). The kernels used for test weight were taken at 14% moisture content. Moisture was measured by a multigrain moisture meter.

Grain yield was calculated on a hectare basis by using the following formulae (Bhandari et al., 2017):

$$\text{Grain yield}\,(\text{Kg ha}^{-1}) = \frac{FEW \times SP \times (100 - GMC)}{NHA \times 86 \times 10}$$

Where, FEW = filled ears weight (Kg), SP = shelling percentage (%)

GMC = grain moisture content at harvest (%), NHA = net harvested area (m^2)

All maize stems were harvested from the base from the net harvested area and weighted immediately after harvesting to calculate stover yield. Husk was also included while taking Stover yield. The harvest produced from the sample row of the individual plot was made into the bundle, and the weight of the bundle was considered biological yield. Harvest index (HI) was computed by dividing economic yield with biological yield. The Grain Stover ratio was computed by dividing grain yield by the stover yield. B: C ratio was computed by dividing gross return with the cost of cultivation.

3. Result and Discussion

3.1 Plant Height

Table 1 represents that The plant height went on increasing from the initial stage to the beginning of the reproductive stage at an increasing rate but later on remained constant or increased at decreasing rate. The differences between plant heights among two maize varieties were significantly different at 30, 45, 60, and 105 DAS while non-significant at 75, 90, 120 DAS. The final plant height was found to be greater for Rampur Composite (198.06 cm) than Rampur Hybrid-6 (185.70 cm). So far, the plant height with respect to nutrient management practices was found to be non-significant among nutrient management practices at all DAS. The highest plant height was found to be in the FFP Dose (196.97cm), followed by LCC (N) (193.07 cm), and the lowest was seen in BR till 120 DAS. At all the growth stages, the interaction effect of varieties and nutrient management practices were found non-significant ($p<0.05$) at all DAS.

Genetic variability among hybrids, open-pollinated varieties (OPV), and inbred lines, its impact on morphological characteristics and plant vigor, and distinct differences in their field performance are well known. The plant height depends upon different traits such as variety, nutrient management, irrigation, intercultural operations, spacing etc. Results showed that the Rampur Composite variety was relatively taller than the Rampur Hybrid-6. The balanced fertilization of maize crops involving a proper nutrient combination of N, P& K applied effectively enhanced the growth parameters like plant height, leaf area, and dry matter. Similarly, other studies have also observed that N fertilizer can increase the maize growth rate by promoting the leaf area index and the photosynthetic source and sink (Uhart and Andrade, 1995). The beneficial effect of optimum and site-specific fertilization on plant height was also observed by several researchers in maize (Pandey et al., 2000; Kumar et al., 2002).

Table 1: Effect of varieties and nutrient management practices on plant height of maize at different growth stages during winter, 2018/19 at Khairahani-5, Chitwan

Factors	**Plant Height (cm)**						
	30DAS	**45DAS**	**60DAS**	**75DAS**	**90DAS**	**105DAS**	**120DAS**
Varieties							
RC	46.40a	63.79a	78.13a	92.81	114.88	172.63a	198.06
RH-6	37.59b	51.14b	62.13b	73.43	96.47	142.13	185.70
SEm±	16.90	35.74	63.17	138.28	156.46	105.94b	108.65
LSDa (0.05)	7.22	10.50	13.96	20.65	21.97	18.07	18.30
CV(a)%	9.8%	10.4%	11.3%	14.15%	11.84%	6.5%	5.43%
F-test	*	*	*	NS	NS	*	NS
NM Practices							
BR	38.96	52.06	64.05	76.16	97.1	149.20	188.00
NE	41.30	57.97	72.52	87.55	113.3	159.73	189.50
FFP	45.03	60.31	71.62	83.35	105.0	158.96	196.97
LCC(N) & NE(PK)	42.03	59.52	72.33	85.42	107.3	161.63	193.07
SEm±	53.73	72.90	73.40	91.32	110.47	150.50	179.15
LSDb (0.05)	9.22	10.74	10.77	12.02	13.22	15.43	16.83
CV(b)%	17.5%	14.8%	12.22%	11.50%	9.9%	7.80%	7%
F-test	NS	NS	NS	NS	NS	NS	NS
Interaction							
F-test	NS	NS	NS	NS	NS	NS	NS
Grand Mean	42.00	57.47	70.13	83.12	105.67	157.38	191.88

Mean followed by common letter(s) within each column are not significantly different ($p<0.05$) by LSD; NS= non-significant, * = significantly different, SEm= Standard Error Mean, LSD=Least Significant Difference, CV= Coefficient of Variation, NM=Nutrient Management

3.2 Above Ground Dry Matter (AGDM)

Table 2 represents that The differences between dry matter means of maize among the two varieties were significantly different at 45 DAS and 90 DAS. The dry matter of the Rampur composite variety was found to be higher than Rampur hybrid-6 till 90 DAS, but after that, the Rampur hybrid-6 variety recorded greater AGDM for 105 DAS and 120 DAS. The AGDM at 120 DAS for Rampur composite was found to be 159.49 g $plant^{-1,}$ while for Rampur hybrid-6, it was 180.49 g $plant^{-1}$. So far, the dry matter production with respect to nutrient management practices was concerned; dry matter production was non-significant at all growth stages except at 120 DAS. The highest dry matter production at 120 DAS was recorded for NE (197.6g $plant^{-1}$), which is significantly different from FFP (155.50 g $plant^{-1}$) and BR (144.66 g $plant^{-1}$) but statistically at par with LCC (N) (182.07 g $plant^{-1}$). The lowest dry matter production was recorded for BR for all growth stages except at 60 DAS, where the lowest dry matter production was for FFP.

At all the growth stages, the interaction effect of varieties and nutrient management practices were found non-significant. The more responsive nature of hybrid varieties to the added nutrients to the soil and more cobs in the case of hybrid varieties compared to the OPV increases dry matter production as the reproductive phase begins. The dry matter production (g $plant^{-1}$) increased as the growth progressed, maximum at 120 DAS. Among the nutrient management practices, site-specific nutrient management (NE) recorded higher dry weight (g $plant^{-1}$) over the blanket recommended dose of fertilizer and farmer fertilizer practice dose. Site-specific nutrient management practices based on NE and LCC (N) proved their distinct superiority over farmer fertilizer practices regarding dry matter accumulation. This result is similar to the finding (Raj et al., 2018). Site-specific nutrient management (NE) had a higher leaf area index indicating a higher chlorophyll area, thus improving the plant's photosynthetic efficiency, resulting in higher dry matter accumulation.

Table 2: Effect of Varieties and Nutrient Management Practices on The Aboveground Dry Matter at Different Growth Stages of Maize During Winter, 2018/19 at Khairahani-5, Chitwan

Factors	Dry Matter Accumulation (g plant^{-1})						
	30DAS	45DAS	60DAS	75DAS	90DAS	105DAS	120DAS
Varieties							
RC	4.106	11.75^{a}	24.66	40.83	63.11^{a}	111.99	159.49
RH-6	3.345	7.31^{b}	16.68	29.54	44.73^{b}	115.90	180.49
SEm±	2.512	5.119	44.34	91.17	78.69	177.55	422.16
LSD$_a$ (0.05)	2.783	3.974	11.69	16.77	15.58	23.40	36.09
CV(a)%	42.5%	23.7%	32.2%	27.13	16.45%	11.69	12.08
F-test	NS	*	NS	NS	*	NS	NS
NM Practices							
BR	3.42	9.90	20.10	32.46	47.54	97.61	144.66^{b}
NE	3.67	10.55	21.17	37.07	55.59	129.77	197.63^{a}
FFP	3.63	8.37	20.93	34.30	54.40	106.57	155.50^{b}
LCC(N) & NE(PK)	4.18	9.31	20.48	36.90	58.13	121.83	182.07^{ab}
SEm±	3.545	13.19	36.65	93.81	316.71	719.33	1092.21
LSD$_b$ (0.05)	2.368	4.56	7.616	12.81	22.38	33.73	39.57
CV(b)%	50.5%	38.09%	29.28%	27.52%	33.00	23.53	19.44
F-test	NS	NS	NS	NS	NS	NS	*
Interaction							
F-test	NS	NS	NS	NS	NS	NS	NS
Grand Mean	3.726	9.535	20.67	35.18	105.67	113.94	169.96

Mean followed by common letter(s) within each column are not significantly different ($p<0.05$) by LSD; NS= non-significant, * = significantly different, SEm= Standard Error Mean, LSD=Least Significant Difference, CV= Coefficient of Variation

The difference among the varieties for dry matter production was noticed. Initially, the dry matter production of Rampur Hybrid-6 was less than the Rampur Composite till 90 DAS, but after that, dry matter was found to be more for Rampur Hybrid-6. This may be due to the more responsive nature of hybrid varieties to the added nutrients to the soil. Also, the number of cobs in the case of hybrid varieties was seen more as compared to the OPV, which increases the dry matter production as the reproductive phase begins. The hybrid cultivar had a strong and thick stem with good root coverage. One of the most important factors for higher dry matter production by hybrid is its good source-sink relationship.

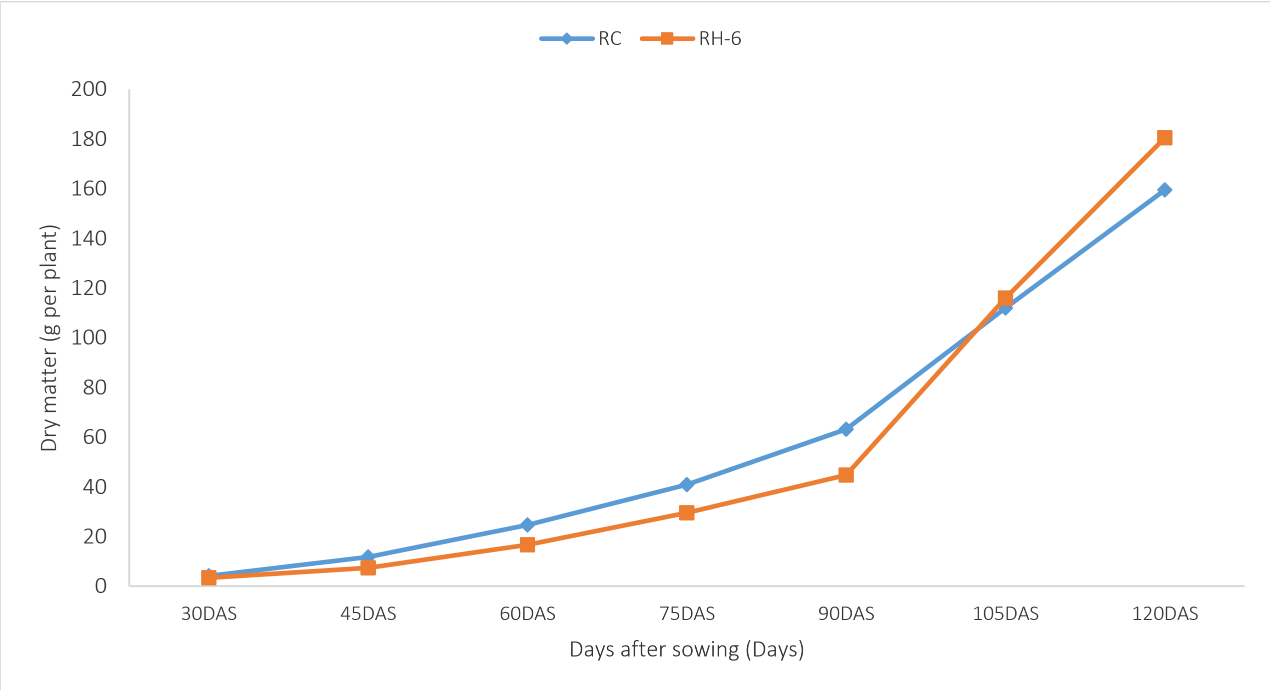

Figure 2: Effect of Varieties on Dry Matter Production of Maize

The dry matter production (g plant^{-1}) increased as the growth progressed, maximum at 120 DAS. Among the nutrient management practices, site-specific nutrient management (NE) recorded higher dry weight (g plant^{-1}) over the blanket recommended dose of fertilizer and farmer fertilizer practice dose. At the initial stages, site-specific nutrient management based on NE-Maize and LCC was comparable to FFP and BR dose of fertilizers but was significantly different at the later stages. However, site-specific nutrient management practices based on NE and LCC (N) proved their distinct superiority over farmer fertilizer practices in respect of dry matter accumulation. This result is similar with the finding of (Raj et al., 2018). The dry matter production is the total sum effect of overall growth. Site-specific nutrient management (NE) had a higher leaf area index indicating a higher chlorophilic area, thus improving the photosynthetic efficiency of plant, resulting in higher dry matter accumulation.

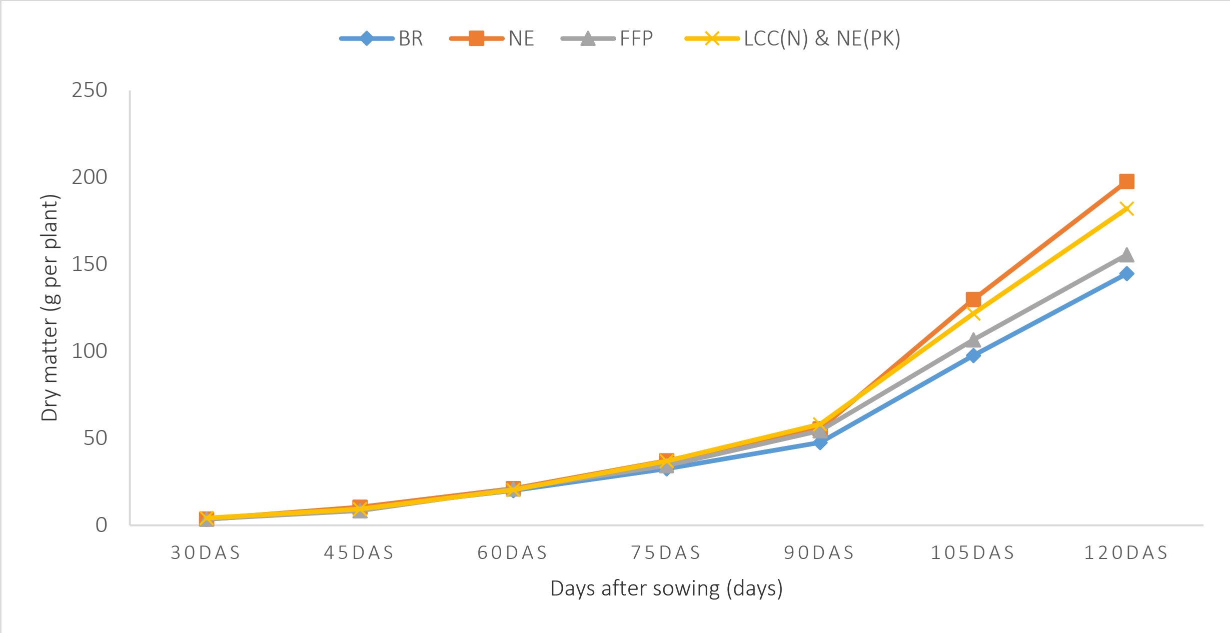

Figure 3: Effect of nutrient management practice on dry matter production of maize

3.3 Leaf Area Index (LAI)

Varieties exhibited mean LAI significantly ($p<0.05$) different at 90 DAS but comparable with other varieties in all the remaining growth stages (30, 45, 60, 75, 105, 120 DAS). LAI of the Rampur composite variety was found to be higher than that of Rampur Hybrid-6 in all growth stages except at 120 DAS, but LAI of both varieties is statistically at par in all growth stages. The highest LAI was found to be at 120 DAS for both Rampur composite (2.801) and Rampur hybrid-6 (3.330) varieties. There is no any significant difference in LAI due to the nutrient management practices in all growth stages, but the highest LAI was obtained for LCC(N) dose (3.393), followed by NE (3.191) and BR (2.857) at 120 DAS. But at 90 DAS, LAI for NE (2.975) was found to be higher than that of LCC (N) (2.583) and FFP (2.450). The LAI of both the varieties for all nutrient management practices was increased continuously from 30 DAS to 120 DAS, but after that, LAI dropped sharply at the time of harvest. The interaction effect of varieties and nutrient management practice was found to be non-significant at all growth stages.

Table 3: Effect of Varieties and Nutrient Management Practices on The Leaf Area Indices (LAI) at Different Growth Stages of Maize During Winter, 2018/19 at Khairahani-5, Chitwan

Factors	Leaf Area Index (LAI)							
	30DAS	45DAS	60DAS	75DAS	90DAS	105DAS	120DAS	At harvest
Varieties								
RC	0.475	0.496	0.770	1.230	2.054[a]	2.679	2.801	1.355
RH-6	0.279	0.360	0.596	0.868	1.717[b]	2.520	3.330	1.181
SEm±	0.018	0.014	0.058	0.068	0.035	0.645	0.274	0.016
LSD_a (0.05)	0.235	0.210	0.423	0.457	0.329	1.411	0.659	0.223
CV(a)%	35.5%	27.91%	35.27%	24.80%	9.95%	30.89%	17.1%	10.01%
F-test	NS	NS	NS	NS	*	NS	NS	NS
NM Practices								
BR	0.379	0.411	0.712	1.224	1.863	2.390	2.857	1.161
NE	0.389	0.396	0.654	0.931	1.809	2.975	3.191	1.303
FFP	0.419	0.511	0.735	1.021	1.964	2.450	2.816	1.152
LCC(N) & NE(PK)	0.321	0.393	0.633	1.022	1.903	2.583	3.393	1.456
SEm±	0.016	0.011	0.018	0.179	0.342	0.265	0.274	0.038
LSD_b (0.05)	0.160	0.134	0.169	0.533	0.736	0.647	0.659	0.246
CV(b)%	33.8%	24.88%	19.61%	40.34%	31.03%	19.78%	17.09%	15.43%
F-test	NS	NS	NS	NS	NS	NS	NS	NS
Interaction								
F-test	NS	NS	NS	NS	NS	NS	NS	NS
Grand Mean	0.377	0.428	0.683	1.049	1.885	2.599	3.064	1.268

Mean followed by common letter(s) within each column are not significantly different ($p<0.05$) by LSD; NS= non-significant, * = significantly different, SEm= Standard Error Mean, LSD=Least Significant Difference, CV= Coefficient of Variation

Hybrids are higher yielders, so they need to develop higher LAI as leaves are the kitchen of the plant body, from where supplements are transported for other structural formations. Initially, the genetic factor played a major role in increasing leaf area, but after the crop nutrient demand for making reproductive parts was increased, hybrids increased their leaf area to a more nutrient-demanding nature for making edible parts. Thus, the LAI of the Rampur composite variety was recorded more, but as the crop proceeds towards the reproductive stage, the LAI of Rampur hybrid-6 recorded significantly higher LAI.

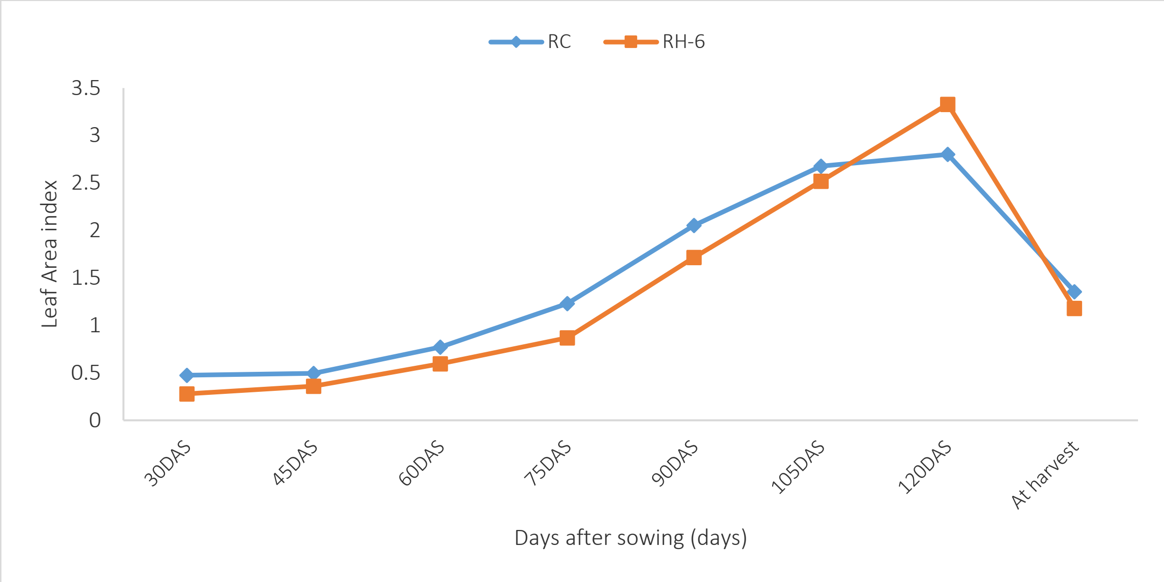

Figure 4: Effect of Varieties on Leaf Area Index of Maize

The leaf area index increased successively as the growth progressed up to 120 DAS. Site-specific nutrient management based on Nutrient Expert (NE) dose and LCC (N) had a higher leaf area index than the blanket recommended dose of fertilizer and farmers' fertilizer practice at 120 DAS as in figure 5. Higher leaf area under site-specific nutrient management has also been reported (Mashego, 2013). When the resources are suboptimal, the leaf growth rate and thus the leaf area index can be limited by the low rate of net photosynthesis or insufficient cell expansion, resulting in a lower leaf area index under farmer's fertilizer practice as site-specific nutrient management had better nutrient supplying capacity as per crop need, resulting in higher leaf growth rate and thereby higher leaf area index.

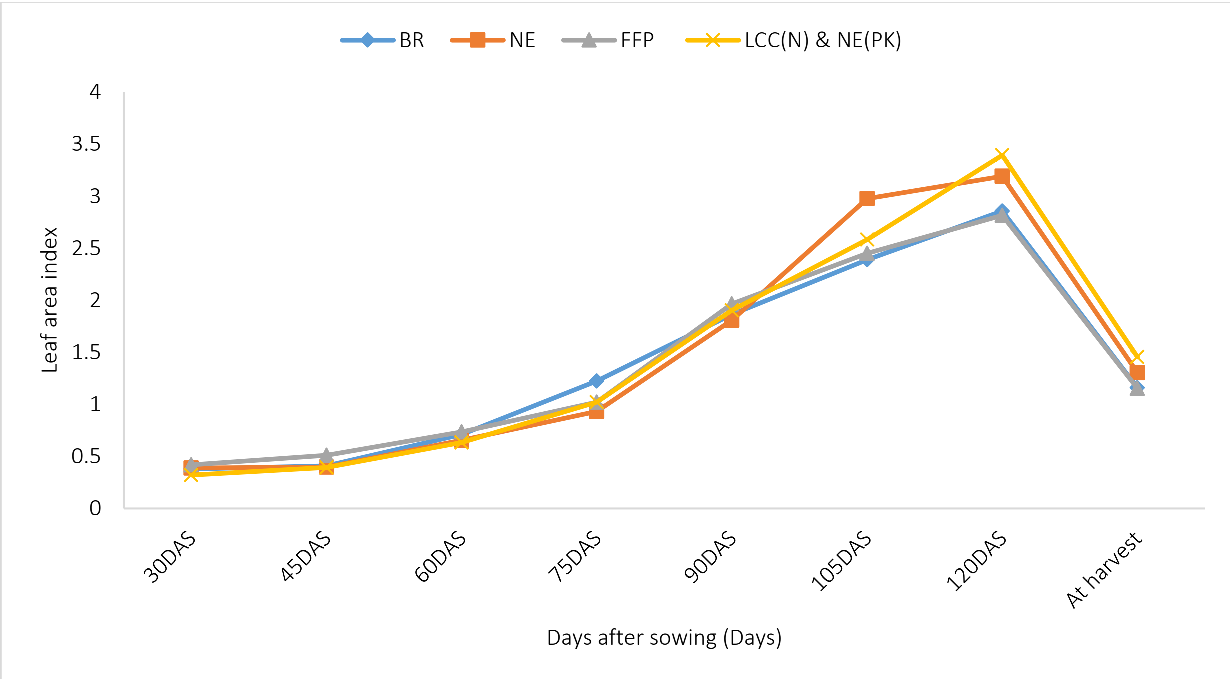

Figure 5: Effect of Nutrient Management Practices on Leaf Area Index of Maize

3.4 Effect on Yield, Yield Attributes, and Production Economics

Table 4 indicates that the number of kernel rows ear^{-1} was found to be non-significantly different among varieties but significantly different due to nutrient management practices. LCC (N) had a significantly higher number of rows ear^{-1} (13.000) than BR (12.067) but was statistically at par with FFP (12.600) and NE (12.533). The highest number of kernels row^{-1} was found to be for NE (25.533), which is statistically at par with LCC (N) (24.833) but significantly different from FFP (22.833) and BR (22.600). The higher number of kernel rows ear^{-1} in LCC (N) may be due to the better grain filling due to the split application of Nitrogen, producing a better source-sink relationship during reproductive stages. The enhanced nutrient availability under site-specific nutrient management led to increased leaf area, photosynthesis, etc. This resulted in the formation of healthy cobs and a higher number of kernels ear^{-1}. In the cultivars, Rampur Hybrid-6 has a greater number of rows ear^{-1} (12.73) and a number of kernels row^{-1}(24.21) than Rampur Composite. The reason for best performance for most of the traits in hybrid might be due to added traits called heterosis.

Thousand-grain weight was found to be highest for NE (357.747), followed by LCC (N) (342.001) and FFP (341.178) but the statistically non-significant difference with all other treatments. The lowest thousand-grain weight was found to be for BR (326.315). The better LAI AGDM during reproductive stages may contribute to better source-sink capacity and help to produce bold and plump seeds. This, in turn, increases the test weight in case of NE dose and LCC (N) dose than a blanket recommendation Grain and stover yields had shown non-significant ($p<0.05$) differences for the two maize varieties. Rampur hybrid-6 had a greater grain yield (5.877 t ha^{-1}) and stover yield (7.636 t ha^{-1}) than the Rampur composite in both grain (5.252 t ha^{-1}) and stover (6.893 t ha^{-1}) yield. This is because OPV maize is less genetic potential than hybrid maize varieties.

The grain yield and stover yield were found to be highly significantly different for four nutrient management practices. The highest grain and stover yield was recorded for NE recommendation (6.399 t ha^{-1} and 9.279 t ha$^{-1,}$ respectively), followed by LCC(N) (6.071 t ha^{-1} and 7.246 t ha$^{-1,}$ respectively). BR had the lowest grain yield (4.482 t ha^{-1}), but in the case of stover yield, FFP recommendation had recorded the lowest stover yield (5.890 t ha^{-1}). This may be due to the proper application of the fertilizers by evaluating the crop nutrient need, and initial soil fertility status is also considered while estimating the dose in NE. The LCC (N) dose based on the leaf greenness also gave a higher yield because it provided the Nitrogen according to the crop needs at the proper time.

Due to varieties, HI and GSR showed non-significant ($p<0.05$) differences. The HI of Rampur hybrid-6 (0.438) was found to be comparable with Rampur composite (0.436). Also, the GSR of Rampur hybrid-6 (0.789) was found to be nearly equal to that of Rampur composite (0.786). Unlike above, HI and GSR were found to be significantly different among nutrient management practices. HI, and GSR of FFP recommendation was found to be highest (0.479 and 0.931 respectively), followed by LCC (N) (0.456 and 0.843 respectively) and NE recommendation (0.410 and 0.699 respectively). The lowest HI and GSR were obtained in BR (0.403 and 0.677, respectively).

Harvest index was found nearly equal for both the varieties, and they were statistically at par. FFP has the highest harvest index, followed by LCC (N) and NE. The insect damage was seen more on the FFP plots, due to which most of the biomass was destroyed after the reproductive parts were formed. This plot's leaves were pale yellow due to the field's water stagnation area, which may decrease the biomass, resulting in higher HI. The BC ratio was also found to be highest for NE (2.47), followed by LCC (N) (2.42) and FFP (2.17). The lowest BC ratio was found to be for BR (1.81). And the BC ratio for Rampur hybrid-6 (2.23) than Rampur composite (2.21) variety. Thus the best nutrient management practice that benefits the farmer was NE.

Table 4: Effect of Varieties and Nutrient Management Practices on Yield Attributing Character, Yield, and Harvest Index of Maize During The Winter Season, 2018/19 at Khairahani-5, Chitwan

Factors	Number Of Rows Ear^{-1}	Number Of Kernels Row^{-1}	Thousand Grain Weight (G)	Grain Yield (T Ha^{-1})	Stover Yield (T Ha^{-1})	Harvest Index	Grain Stover Ratio	Benefit-Cost Ratio
Varieties								
Rc	12.367	23.683	351.64	5.252	6.893	0.436	0.786	2.21
RH-6	12.733	24.217	331.98	5.877	7.636	0.438	0.789	2.23
SEm±	0.187	2.112	2168.12	0.922	3.484	0.001	0.012	0.050
LSD (0.05)	0.759	2.553	81.790	1.687	3.279	0.056	0.189	0.394
CV%	3.4%	6.1%	13.6%	17.3%	25.7%	7.2%	13.7%	10.1%
F-test	NS	NS	NS	NS	NS	NS	NS	NS
NM PRACTICES								
BR	12.067^{b}	22.600^{b}	326.315	4.482^{c}	6.644^{b}	0.403^{c}	0.677^{c}	1.81^{c}
NE	12.533^{ab}	25.533^{a}	357.747	6.399^{a}	9.279^{a}	0.410^{bc}	0.699^{bc}	2.47^{a}
FFP	12.600^{ab}	22.833^{b}	341.178	5.307^{bc}	5.890^{b}	0.479^{a}	0.931^{a}	2.17^{b}
LCC(N) & NE (PK)	13.000^{a}	24.833^{a}	342.001	6.071^{ab}	7.246^{b}	0.456^{ab}	0.843^{ab}	2.42^{a}
SEm±	0.249	1.909	1401.21	0.556	1.857	0.001	0.016	0.036
LSD (0.05)	0.628	1.738	47.088	0.938	1.714	0.048	0.159	0.239
CV%	4%	5.8%	11%	13.4%	18.8%	8.6%	16.1%	8.6%
F-Test	*	**	NS	**	**	*	*	***
Interaction								
F-Test	NS	NS	NS	NS	NS	NS	NS	NS
Grand Mean	12.55	23.95	341.81	5.565	7.264	0.437	0.788	2.22

Note: * Significant at 0.05 level of significance, ** Significant at 0.01 level of significance, *** Significant at 0.001 level of significance. Means followed by the same letter(s) in the same column are not significantly different at a 0.05 level of significance by DMRT.

4. Conclusion

Cultivating maize in the winter season with both Rampur hybrid-6 and Rampur composite varieties is a perfect option for farmers of the central Terai region if site-specific nutrient management practices are adopted. This research found that adopting NE-based recommendations for nutrient management helps to get maximum yield with maximum profit for both the varieties during the winter season in Khairahani, Chitwan. In all nutrient management practices used in the research, the yield of the hybrid variety was slightly more than the composite variety. So we can conclude that nutrient management practice is a major contributor to increasing the yield in case of both the varieties used in research. The study shows the profitability of SSNM (Nutrient Expert) over the blanket recommendation and farmers' nutrient management practices. Thus, site-specific nutrient management based on NE-Maize software should further be researched in different regions to disseminate this nutrient management technique fully.

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