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Vol. 25, Issue 02: 2128-2136
Journal of Bioscience and Agriculture Research
Journal Home: www.journalbinet.com/jbar-journal.html

Site specific nutrient management and its effect on growth and yield of winter maize

N. R. Acharya[1], S. K. Sah[2], A. K. Gautam[3] and A. P. Regmi[3]

[1]Nepal Agricultural Research Council, Directorate of Agricultural Research, Khajura, Banke, Nepal
[2]Agriculture and Forestry University, Rampur, Chitwan, Nepal
[3]Nepal Agricultural Research Council, Singh Durbar Plaza, Kathmandu, Nepal

✉ For any information: navraj.dang@gmail.com (Acharya, NR)
Article received: 21.09.2020; Revised: 07.10.2020; First published online: 20 October 2020.

ABSTRACT

An experiment was conducted on farmer's field in Khajura, Banke for site specific nutrient management (SSNM) in hybrid maize (Rajkumar) during winter season of 2016. The climatic condition of the experimental location was humid sub-tropical and sandy loam soil occurring intense summer and severe winter. Average annual rainfall of 1000 -1500 mm occurs in the location. The experiment was replicated 4 times in Randomized complete block design having plot size of 4.8 x 3 m². Row to row spacing was maintained at 60 cm and plant to plant at 25 cm for each plot. There were six treatments including farmers fertilization practice (27.6:27.6:18 $NP_2O_5K_2O$ kgha^{-1}) as a check, recommended dose of fertilizer (160:60:40 $NP_2O_5K_2O$ kgha^{-1}), site specific nutrient management (212.9:66.8:280.8 $NP_2O_5K_2O$ kgha^{-1}), 75% SSNM (372.6:116.9:491.4 $NP_2O_5K_2O$ kgha^{-1}), FP-N, FP-P, SSNM-K (27.6:27.6:280.8 $NP_2O_5K_2O$ kgha^{-1}) and SSNM-N, FP-P, FP-K (212.9:27.6:27.6 $NP_2O_5K_2O$ kgha^{-1}). Among the treatment combination; application of SSNM we can increase the yield by 193% over farmer fertilization practice. Recommended dose of fertilizer and 75 percent SSNM also increase the yield by 138% and 130.4% respectively compared to farmer fertilization practice. 88% and 53.5% more increment could also be obtained through the application of only SSNM dose of nitrogen and SSNM dose of potassium respectively over farmer fertilization practice.

***Key Words**: Site specific nutrient management, Maize, Hybrid, Grain yield and Nutrient uptake*

Cite Article: Acharya, N. R., Sah, S. K., Gautam, A. K. and Regmi, A. P. (2020). Site specific nutrient management and its effect on growth and yield of winter maize. Journal of Bioscience and Agriculture Research, 25(02), 2128-2136.
Crossref: https://doi.org/10.18801/jbar.250220.60

I. Introduction

Maize (*Zea mays* L.) is the world's widely grown cereal and ranks third most important cereal crops after wheat and rice in the world. Worldwide maize is cultivated in an area of 169.64 million hectares with a production of 882.96 million metric tonnes (USDA, 2012). Out of the total production of maize the United States of America alone produced half of the world's production. China, Brazil, France,

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India, Indonesia and South Africa are other top maize producing countries. World's agricultural economy depends to some extent upon the production and productivity of maize; food for humans and feed for animals. It is the second most important cereal crop after rice in terms of area and production in Nepal. Maize is cultivated in 956447 ha area of land and is the second most important cereal crop after rice 1491744 ha in Nepal (MoALD, 2019). Out of the total cereal production (10685550 Mt) of the country, maize production alone contributes to about 25.3% (2713635 Mt). The national average productivity of maize is 2.8 Mt ha^{-1}. Maize occupies 27.7% out of the total cereal crops cultivating area 3450163 ha of the nation (MoALD, 2019).

Grain yield of a particular genotype of maize depends upon its potentiality of yield components (Grafius, 1960). Gardner et al. (1985) reported that number of ears per unit area, grains per ear and thousand grain weights are the key components for higher yield. Fluctuations in any of these parameters remaining other constant affect the grain yield. Site specific nutrient management is a plant based approach that can be used everywhere. It provides guidelines to the farmers for effective nitrogen, phosphorus and potassium management to the crop. Soil itself does not usually supply enough nutrients to produce high yields therefore supplemental nutrient is necessary. The growth and yield of crop for adding fertilizers to the soil vary greatly among fields and seasons. So, nutrient management for the crop requires a technique that enables management in applying nitrogen, phosphorus and potassium as per needs of the crop.

II. Materials and Methods

The experiment was conducted at Khajura, Banke, Nepal (Figure 01) during winter season 2016. The climatic conditions of the experimental location were intense summer and severe winter. Soil was sandy loam and humid sub-tropical climate. Average annual rainfall of 1000 -1500 mm occurs in the location. However, delayed onset of monsoon rain and earlier termination causes occasional failure of annual crops in the region. The maximum and minimum temperature at the site is 46^{0}C and 5.4^{0}C respectively. The relative humidity ranges between 27 to 94%. The experiment was replicated 4 times in randomized complete block design of plot size 4.8 x 3 m^2. Row to row spacing was maintained at 60 cm and plant to plant 25 cm for each plot. Fertilizer in the form of di –ammonium phosphate (DAP) and murate of potash (MoP) was applied at the time of sowing while half of urea was top dressed at 30-35 days after sowing and the other half at tasseling stage. The SSNM dose was calculated through nutrient expert on software developed by IPNI (Witt et al., 2009) (Table 01) and the experiment of NPK Omission plot technique in the earlier year for targeted yield 8 Mt ha^{-1}. All agronomical practices were done. Rajkumar hybrid at 25 October, 2016 was sown. Following are the treatments under study:

Table 01. Treatment details for maize

SN	Particulars	Doses (Kg ha^{-1})		
		N	P_2O_5	K_2O
1	Farmer practice (T1)	27.6	27.6	18
2	Recommended dose (T2)	160	60	40
3	Site Specific Nutrient Management (SSNM) (T3)	212.9	66.8	280.8
4	75% SSNM dose (T4)	159.7	50.1	210.6
5	FP-N, FP-P, SSNM-K (T5)	27.6	27.6	280.8
6	SSNM-N, FP-P, FP-K (T6)	212.9	27.6	27.6

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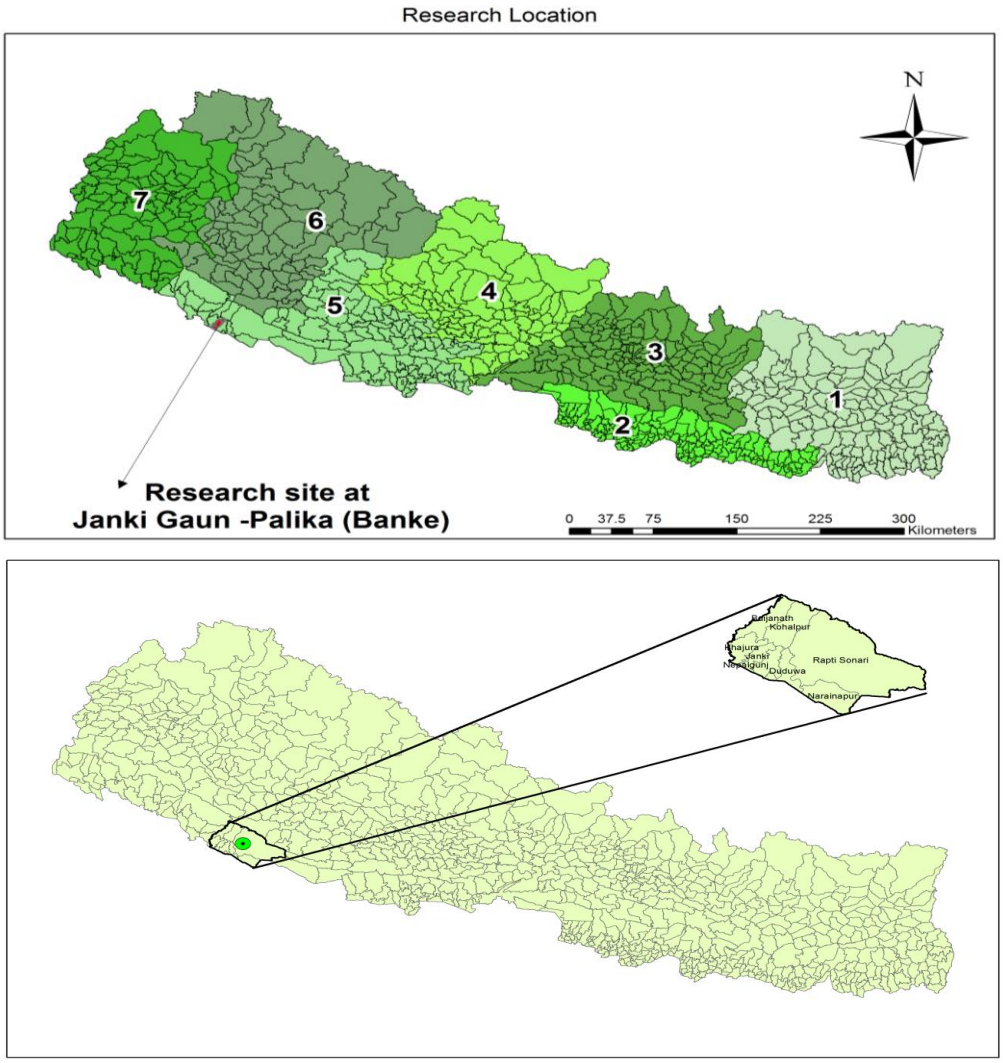

Figure 01. Location map of the experimental plot

III. Results

Above ground dry matter (kg ha^{-1})

Site specific nutrient management had highly significant influence on dry matter accumulation of maize. Analysis of data revealed that the highest dry matter was recorded from site specific nutrient management followed by recommended dose and 75 percent SSNM compared to farmer fertilizer practice (Figure 02). SSNM –K and SSNM –N with farmer fertilizer practice of phosphorus also recorded significantly higher dry matter compared to farmer fertilization practice.

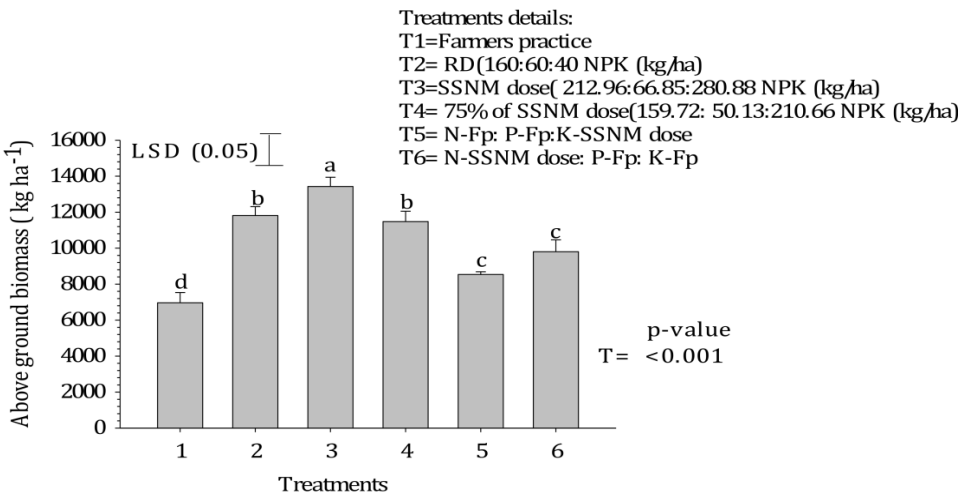

Figure 02. Effect of site specific nutrient management in maize for dry matter accumulation.

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Leaf area index

Site specific nutrient management had highly significant influence on leaf area index. LAI was measured at different time interval from 60 to 135 days after sowing. It was increasing in increasing rate up to 120 days after sowing then afterwards it retards might be due to senescence of leaf at all the treatment combination (Figure 03). It might be due to the active growth stage of maize up to 120 days after sowing. The highest LAI was recorded from site specific nutrient management followed by recommended dose and 75 percent SSNM as compared to farmer fertilizer practice. SSNM –K and SSNM –N with farmer fertilizer practice of phosphorus also recorded the higher LAI as compared to farmer fertilizer practice at all the time interval of data recorded.

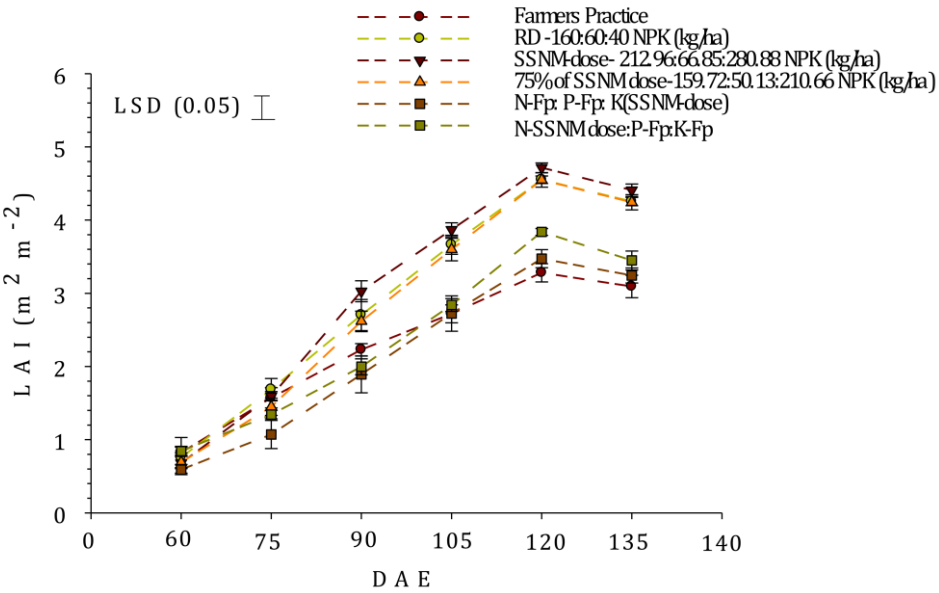

Figure 03. Effect of site specific nutrient management in maize for leaf area index at different time interval.

Number of ears ha^{-1}

The response to number of ears ha^{-1} in different fertilizer combination was significant ($p<0.05$). Number of ears was higher (67604.5 ha^{-1}) in site specific nutrient management dose and recommended dose of fertilizer (67585 ha^{-1}) which was statistically at par with 75% SSNM dose (67370.7 ha^{-1}) and FP –N, FP –P, SSNM –K (67006.8 ha^{-1}) . The least number of ears (64664.3 ha^{-1}) was recorded with SSNM –N, FP –P, FP –K dose (Table 02).

Number of kernels ear^{-1}

The response to number of kernels ear^{-1} in different fertilizer combination was highly significant ($p<0.01$). Maximum (452.9) number of kernels ear^{-1} was recorded in site specific nutrient management dose followed by recommended dose of fertilizer (423.8) application. The least (198.5) number of kernels ear^{-1} was obtained from farmer fertilization practice (Table 02).

Thousand grain weight (g)

The response to thousand grain weight in different fertilizer combination was significant ($p<0.01$). Thousand grain weights in site specific nutrient management dose was significantly higher (328.2 g) which was statistically at par with recommended dose of fertilizer (317.5 g) application. The least thousand grain weight (274.1 g), (283.7 g) and (287.7 g) was recorded from farmer fertilization practice, FP –N, FP –P, SSNM –K and SSNM –N, FP –P, FP –K respectively (Table 02).

Yield parameters

Grain yield of maize differed significantly due to the site specific nutrient management practices. SSNM produce significantly ($p<0.01$) higher grain yield (9785.3 kg ha^{-1}) than farmer fertilization practice (3338.6 kg ha^{-1}). Similarly application of recommended dose (7954.7 kg ha^{-1}) and 75% site specific nutrient management (7694 kg ha^{-1}) of fertilizer also produce significant improvement in yield than farmer fertilization practices (3338.6 kg ha^{-1}). In other words, the yield could be increased by 193% with the application of SSNM dose of fertilizer. Recommended dose of fertilizer could increase the

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yield by 138% and 75 percent SSNM by 130.4% than farmer fertilization practice. 88% more increment could also be obtained through the application of only SSNM dose of nitrogen and 53.5% by SSNM dose of potassium than farmer fertilization practice (Table 03).

Table 02. Response of hybrid maize influenced by site specific nutrient management at Khajura, Banke, Nepal

Treatments	Number of ears ha^{-1}	Number of kernels ear^{-1}	Thousand grain weight (g)
Farmer fertilization practice	65423.6^{ab}	198.5^{f}	274.1^{c}
Recommended dose	67585.0^{a}	423.8^{b}	317.5^{ab}
Site Specific Nutrient Management dose	67604.5^{a}	452.9^{a}	328.2^{a}
75% SSNM dose	67370.7^{ab}	400.5^{c}	305.6^{b}
FP-N, FP-P, SSNM-K	67006.8^{ab}	270.6^{e}	283.7^{c}
SSNM-N, FP-P, FP-K	64664.3^{b}	295.3^{d}	287.7^{c}
F -test	*(0.05)	**(<0.001)	**(<0.001)
LSD (0.05)	2851.4	21.1	14.6
CV %	2.8	4.1	3.2
Grand mean	66609.2	340.3	299.5

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level of significance.

Analysis of data (Table 03) revealed that stover yield of nutrients management practices caused significant effect with SSNM which was significantly higher (13429.2 kg ha^{-1}) than farmer fertilization practice (6963.5 kg ha^{-1}) followed by recommended dose of fertilizer (11810.6 kg ha^{-1}) and 75 percent SSNM (11475.4 kg ha^{-1}). In other words, 92.8% more stover yield could be produced by SSNM, 69.6% by recommended dose and 64.7% by 75 percent SSNM than farmer fertilization practice. 40.7% more stover could also be obtained through the application of only SSNM dose of nitrogen and 22.5% with the application of SSNM dose of potassium than farmer fertilization practice.

Analysis of data revealed that harvest index and grain: stover ratio of nutrients management practices caused significant effect with the application of SSNM than farmers fertilization practices (Table 03). Harvest index of site specific nutrient management was significantly higher (42.15%) as compared to farmer fertilization practice (32.63%) which was at par with recommended dose (40.24%) and 75 percent SSNM (40.05%) dose of fertilizer. In other words, SSNM, recommended dose and 75% SSNM recorded significantly higher harvest index by 29%, 23.3% and 22.7% and grain: stover ratio by 50%, 39.5% and 37.5% than farmer fertilization practice respectively. Application of SSNM –K and SSNM –N only also enhance higher harvest index by 14.9% and 19.3% and grain: stover ratio by 25% and 31.2% higher than farmer fertilization practice.

Table 03. Response of hybrid maize influenced by site specific nutrient management at Khajura, Banke, Nepal.

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Grain: stover ratio
Farmer fertilization practice	3338.6^{e}	6963.5^{d}	32.63^{d}	0.48^{d}
Recommended dose	7954.7^{b}	11810.6^{b}	40.24^{ab}	0.67^{ab}
Site Specific Nutrient Management	9785.3^{a}	13429.2^{a}	42.15^{a}	0.72^{a}
75% SSNM	7694^{b}	11475.4^{b}	40.05^{ab}	0.66^{b}
FP-N, FP-P, SSNM-K	5124.5^{d}	8535.6^{c}	37.51^{c}	0.6^{c}
SSNM-N, FP-P, FP-K	6282.1^{c}	9800.4^{c}	38.96^{bc}	0.63^{bc}
F -test	**<0.001	**<0.001	**<0.001	**<0.001
LSD (0.05)	1104.6	1432.9	2.37	0.05
CV %	10.9	9.1	4.0	5.7
Grand mean	6696.5	10335.8	38.5	0.63

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level of significance.

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IV. Discussion

Above ground dry matter of maize influenced by site specific nutrient management technique

Site specific nutrient management had highly significant influence on dry matter accumulation of maize. The highest dry matter was recorded from site specific nutrient management followed by recommended dose and 75 percent SSNM as compared to farmer fertilizer practice. SSNM –K and SSNM –N with farmer fertilizer practice of phosphorus also recorded significantly higher dry matter as compared to farmer fertilizer practice. Dry matter accumulates maximum when sufficient nitrogenous and potassium fertilizer were used in the field. Increased trend of dry matter was observed with increase in nitrogen and potassium fertilizer rate. Norman and Arkebauer, (1991) reported that carbon fixed by photosynthesis converted to dry matter accumulation of plant. The quantity of radiation absorbed by the canopy in the absence of biotic and abiotic stresses accommodate dry matter of plants (Kiniry et al., 1989; Monteith, 1977; Sinclair and Muchow, 1999).

Leaf area index of maize influenced by site specific nutrient management technique

Site specific nutrient management had highly significant influence on leaf area index. It was increasing in increasing rate up to 120 days after sowing then afterwards it retards might be due to senescence of leaf at all the treatment combination. It might be due to the active growth stage of maize up to 120 days after sowing. The highest LAI was recorded from site specific nutrient management followed by recommended dose and 75 percent SSNM as compared to farmer fertilizer practice. SSNM –K and SSNM –N with farmer fertilizer practice of phosphorus also recorded the higher LAI as compared to farmer fertilizer practice. Generally, increased trend of LAI was observed with increase in nitrogen and potassium too. Optimum nitrogenous fertilizer might have helped to improve the expansion of leaf in plants. (Haghighi et al., 2010) reported increase in nitrogenous fertilizer application increases the LAI on maize. Optimum amount of nitrogen application increases leaf area rapidly in the early stage of development and so LAI value could be sustained longer with an advantage in the assimilate flow to the grain yield and harvest index value (Dobos and Nagy, 1988; Berzsenyi, 1993).

Number of ears ha^{-1}, number of kernels ear^{-1} and thousand grain weight of maize influenced by site specific nutrient management technique

The response to number of ears ha^{-1} in different fertilizer combination was significant. Numbe of ears ha^{-1} in site specific nutrient management dose and recommended dose of fertilizer was significantly higher (67604.5 ha^{-1}) and (67585 ha^{-1}) respectively which was statistically at par with 75% SSNM dose and FP –N, FP –P, SSNM –K. The least number of ears (64664.3 ha^{-1}) was recorded in SSNM–N, FP–P, FP–K dose. Number of ears ha^{-1}, number of kernels ear^{-1} and thousand grain weight recorded higher in site specific nutrient management and recommended dose of fertilizer. Photosynthesis at silking enhances number of kernels which is related with plant growth rate (Edmeadas and Daynard, 1979). Similar results reported by Hargilas et al. (2017). Several authors argue that reduction in yield is mostly due to lower number of ears (Bunting, 1973; Hashemi –Dezfouli and Herbert, 1992), fewer kernels ear^{-1} (Baenziger and Glover, 1980; Karlen and Camp, 1985; Cox, 1996) and lower thousand grain weight (Poneleit and Egli, 1979) or a combination of these parameters.

Grain yield of maize influenced by site specific nutrient management technique

Grain yield of maize differed significantly due to the site specific nutrient management practices. SSNM produce significantly higher grain yield (9785.3 kg ha^{-1}) than farmer fertilization practice (3338.6 kg ha^{-1}). Similarly application of recommended dose and 75% site specific nutrient management of fertilizer also produce significant improvement in yield (7954.7 kg ha^{-1}) and (7694 kg ha^{-1}) respectively over farmer fertilization practices. Harvest index of site specific nutrient management was significantly higher (42.15%) compared to farmer fertilization practice (32.63%) which was at par with recommended dose (40.24%) and 75 percent SSNM (40.05%) dose of fertilizer. Sufficient supply of nutrients contributes towards higher dry matter accumulation, leaf area index and better photosynthesis resulting higher yield components and the grain yield under site specific nutrient management followed by recommended dose of fertilizer and 75% SSNM. Application of SSNM–K and SSNM–N also superior to farmer fertilizing practice. Similar findings reported by Jat et al. (2018). Mehta et al. (2011) also reported that site specific nutrient management techniques increases in grain yield, harvest index and grain: stover ratio.

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Lower availability of nutrients could not meet the higher requirement of nitrogen, phosphorus and potassium required for the crop so there might be higher yield reduction in the farmer fertilizing practice as compared to site specific nutrient management. (Kaini, 2004) also reported that low level of fertilizer use, heavy loss of soil fertility, unavailability of improved variety and minimum use of production technologies are the factors responsible for low yield of maize. Similar findings was reported by (Bangarwa et al., 1989) that winter and spring season maize has higher yield potential over normal season crop and the genotypic constitutions largely determine the response of a variety to chemical fertilizers. (Singh and Zaidi, 1989) reported that longer duration of crop growth, better photosynthesis and best utilization of assimilates contributes to the higher yield of winter and spring maize. Higher efficiency in the uptake and the use of nutrients by the crops also attributed to longer duration of growth, photosynthesis and assimilates supply (Shrestha, 2007). Site specific nutrient management enhanced yields. A study of SSNM conducted by (Pasuquin et al. 2014) in Southeast Asia reported that yield was less at first year but increases by 13% over a three year period. Similar result was also reported by (Nimje and Seth, 1988) and biomass production increased with the increment in nitrogen level (Nunes et al., 1996).

There must be mechanism responsible for accumulating more dry matter in the seeds to increase the yield. A real change in partitioning or increase in assimilates supply and diverting photosynthates to reproductive growth instead of vegetative growth could increase grain yield, reduce vegetative mass and increase the harvest index. Any decrease in vegetative mass from shortening the vegetative growth period could increase harvest index with no change in yield (Egli, 1998).

V. Conclusion

A research was conducted to calculate the optimum use of nutrients that crop needs for its better growth and higher yield applying site specific nutrient management techniques and other fertilization practice as mentioned. SSNM increases 193% more grain yield than the farmers' fertilization practice. Recommended dose of fertilizer and 75 percent SSNM also enhanced the grain yield by 138% and 130% respectively compared to farmer fertilization practice. So after this experiment we can recommend site specific nutrient management (212.9: 66.8: 280.8 $NP_2O_5K_2O$ kg ha^{-1}) the most suitable nutrient management techniques for obtaining higher dry matter accumulation, leaf area index, yield attributes and yield of winter maize.

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HOW TO CITE THIS ARTICLE?

Crossref: https://doi.org/10.18801/jbar.250220.260

MLA

Acharya, N. R. et al. "Site specific nutrient management and its effect on growth and yield of winter maize". Journal of Bioscience and Agriculture Research, 25(02), (2020): 2128-2136.

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Acharya, N. R., Sah, S. K., Gautam, A. K. and Regmi, A. P. (2020). Site specific nutrient management and its effect on growth and yield of winter maize. *Journal of Bioscience and Agriculture Research*, 25(02), 2128-2136.

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EISSN: 2312-7945, © 2020 The Authors, Research paper