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Effect of Crop Geometry and Weed Management Practices on Yield and Yield Attributes of Spring Maize in Banke, Nepal

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A B S T R A C T

The experiment was conducted in Banke, Nepal, from February 2021 to May 2021 to find suitable spacing and weed management practices for spring maize. The experiment was conducted in a split-plot design in which main plots consisting of two spacings (S1:60 cm × 25 cm and S2:60 cm × 30 cm) and subplots consisting of five weed management practices as, W1: weedy check, W2: weed free, W3: atrazine @ 2 kg a.i. ha^{-1} as pre-emergence herbicide, W4: atrazine as pre-emergence herbicide followed by single-hand weeding at 30 DAS, and W5: straw mulch. Observations were taken for different parameters, that are, cob length, cob circumference, number of grains per cob, number of ears per hectare, thousand-grain weight, and grain yield. Based on spacing non-significant variations were found for all traits except for the number of ears per hectare. The highest number of ears per hectare (61667 ears ha^{-1}) was found in S1 (60 cm × 25 cm). Based on weed management practices all the traits were significantly different, except the number of ears per hectare and thousand grain weight. The highest value of grain yield (6.15 mt ha^{-1}) was found in straw mulch, and the lowest grain yield (3.72 mt ha^{-1}) was found in the weedy check. A positive correlation was observed between yield and different weed management practices (WEM) (r = 0.5**) and other yield-attributing traits, that are, number of ears per hectare (NE) (r = 0.62**), the number of grains per cob (NK) (r = 0.82**), cob length (CL) (r = 0.47**), cob diameter (CD) (r = 0.68**), and total grain weight (TGW) (r = 0.52**). A negative correlation was observed between yield and spacing (S) (r = -0.41*).

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Introduction

After rice maize is the second most important crop in Nepal. It has an annual production of 2,231,517 metric tons (mt) and an annual productivity of 2.5 mt ha^{-1} (Ministry of Agriculture and Livestock Development, 2020). It is successfully grown in temperate and subtropical regions of the world and it ranks third in world production after wheat and rice, however, its productivity is higher than other cereals crops (Deshmukh et al., 2009). The normal growth temperature of maize generally lies between 20 ˚C and 25 ˚C. A temperature which is higher than 13˚C is suitable for the formation of leaves, while it should exceed 18˚C during the tassel formation. At the time of silking and during fertilization, a temperature of about 22 ˚C is needed for optimal growth of maize (Shanka & Arba, 2021).

Weeds are a host for insects, pests, and diseases directly responsible for yield reduction (Shrestha et al., 2019). The range of yield loss due to weeds depends on cultivars, species, and number of weeds per unit area, crop-weed competition period, and duration (Sharma et al., 2018). Competition imposed by different weeds is a major problem in spring maize (Singh et al., 2018). Weed causes a reduction in maize yield, which causes higher costs in food production. Weed can cause a 37% to 100% loss in maize (Dahal & Karki, 2014). The nature and intensity of the weed problem in spring maize are relatively different from maize in the rainy season. The emergence of maize and weed starts simultaneously, and the first 20–30 days after sowing are most critical to crop-weed competition in rainy season maize, whereas, in the spring maize, after the first irrigation, weeds emerge most often (Dobariya, 2015). Poor weed management is one of the prime factors that cause the reduction of yield in maize and it depends on the type of weed flora and its intensity (Pant et al., 2021).

Crops can surpass competition against weeds by adjusting higher plant population densities. The higher population densities increase the rapidity of the canopy development which leads to increased canopy radiation interception, which increases crop growth rates and yields (Andrade et al., 2002) and suppresses the growth and competitiveness of weeds (Murphy et al., 1996). The effect of population density on the growth of maize dry matter accumulation per hectare was significantly higher at higher planting densities (133333 plants ha^{-1}) in comparison to lower planting densities at all stages of crop growth (Singh et al., 2015). Significantly higher dry matter production per plant was observed by lowering the planting density to 66000 plants ha^{-1} (60 cm x 25 cm) from higher densities of 83000 (60 cm x 20 cm), 133333 (50 cm x 15 cm), and 166666 (50 cm x 12 cm) plants ha^{-1} during the rainy season on clay loam soils of Udaipur (Rajasthan), (Singh et al., 2015).

Therefore, an attempt was made to assess the effect on yield attributes, and yield of spring maize by using different levels of spacing and weed management practices.

Material and Methods

Seed

To conduct research, a maize variety named Nutan K.H-101 was used. This variety was recommended in Nepal in 2010 AD. Its plant height ranges from 120 cm to 250 cm. This variety matured in about 90–92 days (MoALD, 2020). The productivity of this variety is 6.5 to 8 mt ha^{-1} (MoALD, 2020). This variety is recommended for terai, inner terai, river basins, and up to 700 meters above sea level.

Experimental Design

Split-plot design, with two spacing as the main plot and five weed management practices as subplot treatments with three replications, was done. Treatments consist of the combination of the following two factors (two spacing and five weed-control practices).

Treatment Details

Table 1. Treatment details of the research study

SN	Factor	Symbols
Factor A (main plot): Spacing (S)		
1	60 cm × 25 cm	S1
2	60 cm × 30 cm	S2
Factor B (subplot): weed control practices (W)		
1	Weedy check	W1
2	Weed free	W2
3	Atrazine as pre-emergence	W3
4	Atrazine followed by single hand weeding at 30 DAS	W4
5	Straw mulch	W5

Manure and Fertilizer

Farmyard manure was used as a source of manure. Urea, diammonium phosphate; and muriate of potash were used as chemical fertilizers.

Field Preparation

One deep plowing by the cultivator and two plowing by the rotavator were done for land preparation. The soil was pulverized and leveled three days before sowing on February 17, 2021. The final layout of the experimental field was done on February 20, 2021. Then treatments were applied to respective plots before the sowing of seed.

Plot Size and Plant Population

The plot size consists of 3.6 meters in length and 3 meters in width. Split-plot design was done, the main plots had two spacings, and the subplots had five weed management practices. Maize seeds were planted in two spacings: 60 cm row-to-row and 25 cm plant-to-plant, containing 72 plants per plot, and 60 cm row-to-row and 30 cm plant-to-plant, containing 60 plants per plot. Sowing was done on February 20, 2021.

Methods of Planting

The required number of seeds for each plot was calculated. For planting bold and healthy seeds were selected, and two seeds per hill were dropped manually in the row line.

Manure and Fertilizer Application

FYM was applied at 8 mt ha^{-1} two weeks before sowing and chemical fertilizer was applied at the rate of 120:60:40 kg NPK per hectare. All doses of FYM, P, K, and 1/3 dose of N were applied as a basal dose, whereas, 1/3 dose of N was applied at 30 Days After Sowing (DAS) as the 1st top dressing, and the remaining 1/3 dose of N was applied at 64 DAS as the 2nd top dressing.

Thinning

The thinning operation was done at 30 DAS for all treatments to maintain one plant per hill by removing the extra plants. Diseased, deformed, and off-type plants were replaced with healthy ones by gap-filling at 30 DAS.

Plant Protection

Infestation of borer was seen on maize plants, for which King Killer (Chlorpyrifos 50% EC + Cypermethrin 5% EC) and Kingstar (Emamectin Benzoate 5% SG) were applied. Two sprays of insecticides were done on March 19 and April 8, respectively.

Irrigation

Pre-sowing rainfall occurred two days before sowing. Irrigation was provided four times in the field, viz., at the knee-high stage, pre-tasseling stage, silking stage, and grain-filling stage, respectively. The basin method was used for irrigation.

Weed Management

The weed control methods were used as per the mentioned treatments in the experimental plots. Weeds were allowed to grow along with the maize crop throughout the crop cycle in the weedy check plot. In other plots, respective treatments were applied to control the weed population. Atrazine was used as a pre-emergence herbicide. Its trade name is Atrazine 50 WP. Atrazine was applied four days after the sowing of the maize seed.

Harvesting and Shelling

The cobs from the 10 sample plants were harvested separately for observation, and the rest of the plots were harvested as well. The harvesting was done 101 days after sowing on June 1, 2021, when the plant turned yellow with brown ear husks and a black layer appeared at the base of each cob when detached.

Data Collection

Number of ears per hectare

The total ears harvested from the net plot area of all plots were recorded and converted to harvested ears per hectare. Further, ten ears were selected from each net plot to analyze the following yield attributing character.

Number of grains per cob (NK)

The number of grains per cob, weight of ear with grains, the weight of grains per ear, cob length, and cob circumference were calculated from the ten randomly selected de-husked ears.

Thousand-grain weight, or test weight (TGW)

From the bulk of shelled grains in each plot thousand grains were selected and weighed with the help of an electronic balance.

Cob length (CL)

Cob length was taken with the help of measuring tape, five cobs from each plot.

Cob circumference (CC)

The cob circumference was taken in three positions (narrow end, middle, and broad end) for each cob from five cobs from each plot.

Grain yield (YLD)

Grain yield was taken from the ear of the plant of the central three rows of each plot. The ears were subjected to dried, threshed, and cleaned, and the final weight was measured. The grain yield per hectare was computed for each plot. Grain yield (YLD, mt ha^{-1}) was calculated at 15% moisture using the following formula:

$$\mathrm{YLD} = \frac{\mathrm{FEW} \times \mathrm{S} \times (100 - \mathrm{GMC}) \times 10}{\mathrm{NHA} \times 85}$$

YLD: Grain yield (YLD, mt ha^{-1})
FEW: Field ear weight
S : Shelling %
GMC: Grain Moisture Content
NHA: Net harvest area

Statistical Analysis

Recorded data were compiled and arranged systematically, treatment-wise, under three replications. The final data were subjected to analyses of variance. The Genstat package (18th edition) was used for data analysis. For data input, simple statistical analysis, and the construction of graphs, MS Excel was used. Microsoft Office Word was used for word processing. An ANOVA was constructed to test the significance difference for each parameter at a 5% level of significance. A simple correlation was established among the selected parameters.

Results and Discussion

Cob Length (CL)

No significant difference was seen in cob length due to spacing. However, weed management practices show significant differences in cob length. Cob length (18 cm) was found higher on weed-free treatment (W2), atrazine as pre-emergence (W3), atrazine followed by hand weeding at 30DAS (W4), and straw mulch (W5). Whereas, the lowest cob length (15 cm) was found in the weedy check treatment (W1) (Table 1).

A significant positive correlation was observed between cob length and weed management practices (WEM) ($r = 0.51^{**}$), yield (YLD) ($r = 0.47^{**}$), and number of grains per cob (NK) ($r = 0.61^{**}$). Indicating an increase in cob length increases the grain yield and better weed management practices increase the cob length. A negative correlation was found between cub length (CL) and the number of ears per ha (NE) (r = -0.05), indicating that an increase in the number of ears per ha decreases cob length (Table 2).

Table 2. Mean values, F test, LSD (0.05), CV, and SEm of different yield attributing traits and yield of Nutan K.H.101 variety of maize as influenced by spacing and weed management practices tested at Nepalgunj, Banke in 2021.

Particulars	CL	CC	NE	NK	TGW	YLD
Factor A, Spacing						
S1(mean)	17	13	61667^{a}	396	241	5.94
S2 (mean)	18	13	54074^{b}	392	232	4.89
F test	NS	NS	*	NS	NS	NS
LSD (0.05)	2.4	0.8	4847	10.5	55	1.63
CV (%)	3.8	1.7	2.4	0.8	6.6	8.6
SEm±	0.4	0.1	796.5	1.7	9	0.268
Factor B, Weed management practices						
W1 (mean)	15^{b}	12^{b}	57407	279^{d}	222	3.72^{c}
W2 (mean)	18^{a}	13^{a}	59877	443^{ab}	245	6.02^{ab}
W3 (mean)	18^{a}	13^{a}	56173	377^{c}	230	5.42^{b}
W4 (mean)	18^{a}	13^{a}	57253	403^{bc}	245	5.76^{b}
W5 (mean)	18^{a}	13^{a}	58642	467^{a}	238	6.15^{a}
Grand mean	18	13	57870	394	236	5.41
F test	**	**	NS	**	NS	**
LSD (0.05)	1.8	0.4	3794	56.3	23.1	1.01
CV (%)	8.3	2.6	5.4	11.7	7.5	15.2
SEm±	0.6	0.1	1265.5	18.8	7.2	0.336

Where NS indicates non-significance and * and ** indicates significance at 5% and 1% level of significance respectively. NE = number of ears per ha, NK = number of grains per cob, CL = cob length (cm), CC = cob circumference (cm), TGW = 1000 grain weight (gm), and YLD = yield (mt ha^{-1}).

Table 3. Pearson correlation coefficients among yield and yield attributing traits of Nutan K.H 101 variety maize with two levels of spacing and five levels of weed management practices tested at Nepalgunj Banke in 2021

	S	WEM	NE	NK	CL	CC	YLD
WEM	0.000 1.000						
NE	-0.777** 0.000	-0.004 0.981					
NK	-0.026 0.892	0.641** 0.000	0.288 0.122				
CL	0.258 0.169	0.511** 0.004	-0.049 0.798	0.610** 0.000			
CC	-0.028 0.884	0.540** 0.002	0.199 0.292	0.635** 0.000	0.441* 0.015		
YLD	-0.405* 0.026	0.499** 0.005	0.619** 0.000	0.818** 0.000	0.470** 0.009	0.678** 0.000	
TGW	-0.228 0.226	0.237 0.208	0.334 0.071	0.315 0.090	0.352 0.056	0.278 0.136	0.516** 0.003

Where, * and ** indicate significance at 5% and 1% levels of significance respectively. S = spacing, WEM = weed management practices, NE = number of ears per ha, NK = number of grains per cob, CL = cob length (cm), CC = cob circumference (cm), TGW = 1000 grain weight (gm) and YLD = yield mt ha^{-1}

This finding was similar to the findings obtained by Raut et al. (2017), who found that cob length is positively correlated with yield, i.e., an increase in cob length results in an increase in yield.

Cob Circumference (CC)

A non-significant difference was found for cob circumference due to spacing, but significant results were found based on weed management practices. The highest cob circumference (13 cm) was found on weed-free treatment (W2), atrazine as pre-emergence (W3), atrazine followed by hand weeding at 30DAS (W4), and straw mulch (W5) (Table 2).

A significant positive correlation was observed between cub circumference (CC) and weed management practices (WEM) (r = 0.54**), number of grains per cob (NK) (r = 0.635**), and yield (YLD) (r = 0.68**). A negative correlation was found between cub circumference (CC) and spacing (S) (r = -0.03), indicating an increase in spacing decreases cob circumference (Table 2).

This finding was similar to the findings obtained by Raut et al. (2017), who found that cob circumference is positively and significantly correlated with yield and the number of grains per cob.

Number of Ears Per Hectare (NE)

Non-significant variation was found in the number of ears per hectare due to weed management practices, but highly significant results were found based on spacing. Spacing of 60 cm × 25 cm (S1) observes the highest number of ears per hectare (61667), which indicates by decreasing the spacing from 60 cm × 30 cm (S2) to 60 cm × 25 cm (S1), we can increase the number of ears per hectare (Table 2).

This finding did not support the previous findings obtained by Shrivastav et al. (2015), who observed that the number of ears per hectare is significantly higher in other treatments of weed management than in the weedy check treatment.

A significant positive correlation was observed between the number of ears per hectare (NE) and yield (YLD) (r = 0.62**), which indicates increase in the number of ears per hectare (NE) increases the yield (YLD). A negative correlation was observed between the number of ears per hectare (NE) and spacing (S) (r = -0.78$^{**)}$, indicating that an increase in spacing decreases the number of ears per hectare significantly.

Number of Grains Per Cob (NK)

There was no significant variation in the number of grains per cob due to spacing, but a highly significant result was found due to weed management practices. The straw mulch (W5) recorded the highest number of grains per cob (467), followed by weed-free (W2) with 443 grains per cob. Whereas, the lowest NK (279) was found in the weedy check treatment.

A significant positive correlation was observed between NK and YLD, WEM, CL, and CD, with values of YLD (r = 0.82**), WEM (r = 0.64**), CL (r = 0.61$^{**),}$ and CC (r = 0.65**), whereas, a negative correlation was found between NK and spacing (S) (r = -0.03).

This finding was similar to the previous finding obtained by Raut et al. (2017) who found that NK per cob is positively highly significant with yield. NK is positively and significantly correlated with cob length and cob diameter

Thousand Grain Weight (TGW)

Non-significant variation was found in the thousand-grain weight based on spacing and weed management practices.

This finding disagrees with the previous findings obtained by Shrivastav et al. (2015), who found that in weedy check plots, the TGW is low, and in weed-free plots and other treatment plots, the TGW is higher than in weedy check plots.

However, a positive correlation was found between thousand-grain weight (TGW) and yield mt ha^{-1} (YLD) (r = 0.52$^{**)}$, indicating that TGW directly determines the yield.

Yield (YLD)

A significant difference was found in yield (YLD) due to different weed management practices. Grain yield (6.15 mt ha^{-1}) was observed highest in straw mulching (W5), followed by weed-free (W2) with a grain yield of 6.02 mt ha^{-1}. Whereas, in weedy check (W1) the lowest grain yield (3.72 mt ha^{-1}) was observed (Table 2).

This finding was similar to the previous findings obtained by K.C. et al. (2015), Reddy et al. (2012), and Singh et al. (2007), who reported significantly higher grain yield in maize under weed-free treatments in comparison to farmers' practice of weed management treatments, and a significant decrease in grain yield in weedy check as compared to other treatments.

A significant positive correlation was found between yield (YLD) and weed management practices (WEM) (r = 0.5**) and other yield-attributing traits: number of ears per hectare (NE) (r = 0.62**,), number of kernels per cob (NK) (r = 0.82**), cob length (CL) (r = 0.47**), cob circumference (CC) (r = 0.68**), and total grain weight (TGW) (r = 0.52**). It indicates a positive relationship between weed management practices and the number of ears per ha, cob length, cob circumference, number of kernels per cob, and thousand-grain weight of spring maize. A significant negative correlation was seen between yield and spacing (r = -0.41*), indicating an increase in spacing decreases yield (Table 3).

This finding agrees with the previous findings obtained by Raut et al. (2017) who observed a significant positive correlation between yield and all yield-attributing traits, viz., NE, NK, CL, and CD. It indicates that increases in better weed management practices, number of ears per cob, cob length, cob circumference, and number of grains per cob increase the yield.

Conclusion

This research showed that the yield of the spring maize does not change significantly by increasing plant-to-plant spacing from 25 cm to 30 cm. Straw mulching was found to be more effective than other weed management practices in terms of yield, number of grains per cob, cob length, and cob circumference in the spring maize. The weedy check showed the lowest yield, number of grains per cob, and cob length than other weed management practices, which shows that the yield of the spring maize can be improved by applying appropriate weed management practices.

Declarations

Author's Note

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the data and the paper are free of plagiarism

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References

Andrade, F. H., Calviño, P., Cirilo, A., & Barbieri, P. (2002). Yield responses to narrow rows depend on increased radiation interception. *Agronomy Journal*, *94*(5), 975–980.

Dahal, S., & Karki, T. B. (2014). Conservation agriculture-based practices affect the weed dynamics in spring maize. *World Journal of Agricultural Research*, *2*(6A), 25–33.

Deshmukh, L., Jadhav, A., Jathure, R., & Raskar, S. (2009). Effect of nutrient and weed management on weed growth and productivity of kharif maize under rainfed condition. *Karnataka Journal of Agricultural Sciences*, *22*(4), 889–891.

Dobariya, A., V. K. and Mathukia, R. K. and Gohil, B. S. and Shivran. (2015). Integrated weed management in rabi sweet corn (Zea mays var. Saccharata). *Journal of Eco-friendly Agriculture, 10*(1), 70–73.

KC, Govind & Karki, Tika & Shrestha, Jiban & Achhami, Buddhi. (2015). Status and prospects of maize research in Nepal. *Journal of Maize Research and Development*, 1, 1-9.

Ministry of Agriculture and Livestock Development (MoALD). (2020). Krishi Diary 2080 . https://aitc.gov.np/en/resources /t02u8l1dz23abqozzz3vlvntvbgta1reos0xbzy9

Murphy, S. D., Yakubu, Y., Weise, S. F., & Swanton, C. J. (1996). Effect of planting patterns and inter-row cultivation on competition between corn (Zea mays) and late emerging weeds. *Weed Science*, *44*(4), 865–870.

Pant, C., Sah, S. K., Marahatta, S., & Dhakal, S. (2021). Weed dynamics in no-till maize system and its management: A review. *Agronomy Journal of Nepal*, *5*(01), 168–177.

Raut, S. K., Ghimire, S. K., Kharel, R., Kuwar, C. B., Sapkota, M., & Kushwaha, U. K. S. (2017). Study of yield and yield attributing traits of maize. *American Journal of Food Science and Health*, *3*(6), 123–129.

Reddy, M. M., Padmaja, B., Veeranna, G., & Reddy, D. V. V. (2012). Bio-efficacy and economics of herbicide mixtures in zero-till maize (Zea mays) grown after rice (Oryza sativa). *Indian Journal of Agronomy*, *57*(3), 255–258.

Shanka, A. S., & Arba, Y. (2021). Evaluation of Maize Crop Water Requirement Under Changing Climate over Konso, Southern Ethiopia.Environmental Analysis & Ecology Studies ,8 (1), 856–863. https://doi.org/10.31031/EAES.2021.08.000679

Sharma, S., Marahattha, S., Sah, S. K., & Karki, T. B. (2018). Efficacy of different tillage and weed management practices on phenology and yield of winter maize (Zea mays L.) in Chitwan, Nepal. *International Journal of Plant & Soil Science*, *26*(2), 1-11.

Shrestha, A., Thapa, B., & Kandel, S. (2019). Assessment of different weed management practices in yield and yield attributes in summer maize in inner Terai of Nepal. *Journal of Research in Weed Science*, *2*(3), 224-229.

Shrivastav, N., Dhakal, M., Amgain, L. P., & Karki, T. B. (2015). Weed dynamics and productivity of spring maize under different tillage and weed management methods. *Azarian Journal of Agriculture*, *2*(5), 118–122.

Singh, K., Kaur, T., Bhullar, M. S., & Brar, A. S. (2018). The Critical period for weed control in spring maize in North-West India. *Maydica*, *61*(1), 7.

Singh, Ganesh & Kumar, Satish & Singh, Rajesh & Singh, S.S. (2015). Growth and yield of Baby Corn (Zea Mays L.) as influenced by varieties, spacings, and dates of sowing. *Indian Journal of Agricultural Research*, 49, 353.

Singh, R., Sharma, A., & Bewera, U. (2007). Tillage and crop establishment practices for improving the productivity of maize (Zea map) under different weed control methods. *The Indian Journal of Agricultural Sciences*, *77*(11).