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Research Article

Effects of row spacings and varieties on grain yield and economics of maize

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ABSTRACT

Maize is the second most important crop of Nepal. The yield of the crop is low due to lack of appropriate plant density for the varieties. The field experiment was carried out to study the effect of different row spacings on different maize varieties at Deupur, Lamahi municipality of the dang district in province No. 5, Nepal during the rainy season from June to September, 2018. Four levels of spacings (boardcasting and three row spacings of 45, 60 and 75 cm) and two maize varieties (Rampur Composite and Arun-2) were evaluated using randomized complete block design with three replications. The highest grain yield was found in Rampur Composite and Arun-2 while they were planted with row spacing of 60 cm with plant to plant spacing of 25 cm. The highest grain yield, cob length, cob circumference, number of rows per cob, thousand grain weight were reported when maize was planted in the row spacing 60×25cm. Among the maize varieties, Rampur Composite produced the highest grain yield, cob length, cob circumference, number of rows per cob as compared to Arun-2. This study suggested that maize production can be maximized by cultivating maize varieties with row spacing of 60 cm with plant to plant spacing of 25 cm.
Keywords: Maize, growth, yield, economics, inter row spacing

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INTRODUCTION

Maize or corn (*Zea mays* L.) has prodigious genetics yield potential, hence, globally known as queen of cereal because of versatile characteristics that subsume, carbon pathway (C4), wider suitability and adaptability to varied agro-climatic, higher multiplication ratio, supreme transpiration efficiency, desirable plant ideotype and multipurpose uses. Maize (900288 ha) is the second most important crop in Nepalese agriculture after rice (1552469 ha) in terms of area. The production of maize in the country is 2,300121 tons with the productivity of 2.5 t/ha (MoAD, 2017).

The majority of farmers are not aware much about information on crop management aspects, especially optimum row spacing, suitable variety and maintaining optimum plant population per hectare. Conventional broadcast of maize sowing method has a lot of defect includes, trouble to establish a correct plant population, trigger off inter plant and intra plant competition; provide uneven opportunity for all plants for nutrients, water and light. The Broadcasting method produced the most effective spatial arrangements. It generally gave lower yields than sowing in rows (Krezel & Sobkowicz, 1996).

Hence, there is a scope to heighten the maize productivity via several agronomic manipulations. Spacing is usually relies on expected growth of specific crop in given agro-climatic condition and determining controlling factor in their growth, development and yield. Agronomic management, especially row spacing which significantly influence on yield, since it is ultimately correlated with plant population, root development, plant growth and fruiting (Davi et al., 1995). The relationship between yield and spacing is intricate. Optimum plant population is vital for maintaining to exploit maximum natural resources such as nutrient, sunlight, soil moisture and to ensure maximum economic grain yield per production area. It exerts decisive influence on maize growth and yield, which outcome timely inception of vegetative and reproductive development. Maize differs in its responses to plant density (Luque et al., 2006). Closer row spacing leading to overcrowding, enhanced interplant competition for incident photosynthetic photon flux density and soil rhizosphere resource, resulting reduction yield per plant because it's influence hormonally mediated apical dominance, exaggerated barrenness, and finally decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001). Wider row spacing causes low density of population promotes dense vegetative growth, increased weed density due to more feeding area available and remain nutrient and moisture unutilized thereby decrease in total yield. However, under high population density, cumulative yield is higher per production area, but drops yield per plant. The appropriate row spacing outcome optimum plant population per area for optimum yield. The best optimum spacing is one, which enables the plants to make the better use of the conditions at their disposal (Lawson & Topham, 1985; Malik et al., 1993). Another factor which influences yield is selection of appropriate varieties. IITA (2001) and Iken et al. (2001) uncovered that open-pollinated maize varieties are more felicitous to farmers since the seeds can be used as planting materials for subsequent cropping season. Worku and Zelleke (2007) revealed that open-pollinated maize varieties produced higher yields than local varieties due to their more efficient in transferring assimilates to their ear sink. Hence, this experiment is conducted to evaluate two OPV maize available in the market to study the effect of row spacing on yield and yield attributing characteristics to

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convey information on agronomic management practices, i.e. optimum row spacing and best improved OP maize varieties to maximizing productivity of maize of our major goal.

MATERIALS AND METHODS

Experimental site

The study was conducted at Deupur, Lamahi municipality of dang district in province No. 5 in Midwestern Nepal during June to October, 2018. Geographically, it is located at 27.04'N latitude and 82.3018'E longitude at the elevation of 300 masl.

Plant materials

Two maize varieties namely Rampur Composite and Arun-2 were received form National Maize Research Program, Rampur, Chitwan, Nepal

Experimental design and cultural practices

The experiment was laid out in factorial Randomized Complete Block Design with three replications. Two maize varieties were evaluated under four levels of row spacings (Table 1). The plot size was 6m2 (3m x 2m) where the length of a block was 28 m. The space between blocks and treatments was 0.5 m. Two boarder rows in each side were treated as non-sampling rows. The remaining central rows were treated as net plot and used for final harvesting.

Table 1. Different levels of maize varieties and row spacings used as treatments in the experiment

S.N.	Factors
Varieties	
1	Arun-2
2	Rampur composite
Row spacings	
1	Broad casting
2	45 cm x 25 cm
3	60 cm x 25 cm
4	75 cm x 25 cm

Fertilizer @ FYM 10 t/ha and 120:60:40 kg NPK/ha was applied for each experiment. Half dose of nitrogen and full dose of phosphorous and potash was applied as basal dose at the time of final land preparation and remaining half of nitrogen was divided into two; one part applied at 20-24 days after sowing and second 40-45 days after sowing. Weeding and irrigation was done as per recommendations of National Maize Research Program, Rampur, Chitwan, Nepal.

Field measurements

Cob length, cob circumference, no. of kernels/eat, thousand grain weight, stover yield, harvest index and grain yield were recorded. Grain yield (kg/ha) was adjusted at 15% moisture content with the help of the below formula:

Grain yield (kg/ha) at 15% moisture content was calculated using fresh ear weight with the help of the below formula:

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$$\text{Grain yield}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{F.W.}\left(\frac{\text{kg}}{\text{plot}}\right) \times (100 - \text{HMP}) \times \text{S} \times 10000}{(100 - \text{DMP}) \times \text{NPA}}$$

Where,

F.W. = Fresh weight of ear in kg per plot at harvest
HMP = Grain moisture percentage at harvest
DMP = Desired moisture percentage, i.e. 15%
NPA = Net harvest plot area, m2
S = Shelling coefficient, i.e. 0.8

This formula was also adopted by Carangal et al. (1971), Shrestha et al. (2019), Shrestha et al. (2018), Gurung et al. (2018), Sharma et al. (2019), Sharma et al. (2016) and Bartaula et al. (2019) to adjust the grain yield (kg/ha) at 15% moisture content. This adjusted grain yield (kg/ha) was again converted to grain yield (t/ha).

Economics analysis

Cost of cultivation

Cost of cultivation of the crop was estimated based on the inputs needed like labor, fertilizer, compost, seed, land rent and other research materials needed. It was calculated on the basis of prevailing market price at Dang district.

Gross return

Biomass yield Grain yield of maize was converted into gross return (Rs /ha) on the basis of prevailing market price.

Net return (Rs /ha)

It was calculated by deducting the cost of cultivation from the gross return.

$$\text{Net return} = \text{Gross return} - \text{cost of cultivation}$$

B: C ratio

It was calculated by following formula,

$$\text{B: C ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Statistical analysis

The experimental data were processed by using Excel 2010 and analyzed by using Genestat 13.2. The experimental data were processed by using Excel 2010 and analyzed by using Genestat 13.2. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT). The treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez & Gomez, 1984; Shrestha, 2019).

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RESULTS AND DISCUSSION

Cob length

Cob length somewhat, is reconciled to the number of grains per row and affects the total number of grains per cob and grain yield. The data on up bearing are presented in table 2, demonstrated that varieties and different row spacing significantly enhanced cob length up bearing. Average mean cob length up bearing was found 14.8 cm. Maximum cob length up bearing (15.5 cm) was obtained in the case of Rampur composite variety as compared to Arun-2 (14.5 cm). Similarly, the cob length up bearing was statistically increased with increase of row spacing. Maximum cob length up bearing (15.9 cm) was recorded under row spacing 75cm × 25cm which was statistically at par with rows pacing 60 cm x 25 cm (15.8 cm).

Cob circumference

Statistical perusal of findings demonstrated that varieties influence on cob circumference. Average mean of cob circumference was found 12.2 cm. Statistically, Rampur composite produced greater cob circumference 12.5 cm as compared to Arun-2 (12 cm). Different inter-row spacing significantly ($p<0.05$) influenced cob circumference. Inter- Row spacing 75 cm x 25 cm was found to result greater cob circumference (13.1 cm), which was statistically similar to row60 cm x 25 cm result (12.6 cm) followed by row spacing 45 cm x 25 cm (12.0 cm) and minimum cob circumference was found in broadcast (11.4 cm).

No. of kernel rows per ear

The data on the number of rows per cob are presented in table 2, which indicate significant ($p<0.05$) change in no of row per cob due to varieties. Average mean of no. of row per cob was found (12.3). Rampur composite was shown statistically higher no. of row per cob (12.6) as compared to Arun-2 (11.9). Different row spacing influence on no. of row per cob. While highest no. of row per cob (12.7), was found significantly under row spacing 75 cm x 25 cm which was Statistically at par with row spacing 60 cm x 25 cm (12.5) followed by row spacing 45 cm x 25 cm (12.1) and minimum no. of row per row per was found in broadcast (11.7). While, interaction between different row spacing and varieties had statistically no significant effect on the number of rows per cob.

Thousand grain weight

Grain weight exemplifies the development and plumpness of grains and is a cardinal indicator of grain yield. The data on the number of rows per cob are presented in table 2, which revealed a significant ($p<0.05$) change in 1000 grain weight due to a different row spacing Average mean of thousand grain weight was found 268 g. Row spacing of 75 cm x 25 cm produced most extreme 1000 grain weight (292.6 g) which was found statistically at par with row 60 cm x 25 cm (290.3 g).Similarly, Broadcast produced lower 1000 grain weight (236.6 g). One of the yield components 1000 grain weight reflects the photosynthetic capability of the plant and its ability to channel photosynthates into essence plant sinks and organs (Rizwan et al., 2003). These outcomes are incongruous with those of Shah et al. (2001) who cited 75 cm row spacing produced inordinately 1000 grain weight. The reason behind the higher thousand grain weight in 75 cm row spacing could be as a result of high light capture and less competition for water outcome in greater accretion of photosynthates.

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Grain yield

Grain yield of a crop is the vector sum of the interaction of several elements and is a well-grounded standard for comparison the efficiency of different treatments. The final objective overall agronomic studies are to maximize the yield of any crop. Statistical perusal of the data uncovered that effect of varieties was found significant on grain yield. Average mean of grain yield was recorded 3.3 t/ha. Statistically, Maximum grain yield (3.5 t/ha) was obtained in Rampur variety as compared to Arun-2 (2.9 t/ha).While, different row spacing significant influence on maize grain yield. Maximum grain yield (3.8 t/ha) was obtained under row spacing of 60 cm x 25 cm followed by row spacing 75 cm x 25 cm (3.5 t/ha) which was statistically indifference with inter-spacing 45 cm x 25 cm results (3.2 t/ha). Minimum grain yield (2.5 t/ha) was produced Statistically under Broadcast This may be because of the way that 60 cm row spacing have made better soil conditions for significant root improvement and effective supply of supplements. Our resultant was commensurate with those of Luquevet et al. (2006) found that grain yield per plant is plummet due to less light and other ecological resource availability. Furthermore, Moririet et al. (2010) found that more plant population engendered pressure, competition in plants, hence, curtailed plant development in maize. This may be because of the way that wider row spacing gave lush condition for efficient root improvement and plant development. The results are incongruity with Abuzar et al. (2011) who found that least grain yield at the most population.

Stover yield

Statistical analysis revealed a significant ($p<0.05$) change in Stover due to a different row spacing and varieties and interaction of row spacing and varieties had no significant on Stover yield. Average mean of Stover yield 6 t/ha was obtained in the case of varieties Maximum Stover yield was found in Rampur composite (7.2 t/ha) and minimum Stover yield was found in Arun-2 (4.8 t/ha) In case of different Row spacing, maximum Stover yield was recorded in row spacing 60 cm x 25 cm (7 t/ha) which was statistically similar to row spacing 60 cm x 25 cm results (6.6 t/ha). Consequently, minimum Stover yield was recorded in broadcast (4.6 t/ha).

Harvest index

Harvest index indicates the efficiency of assimilating partition to the parts of economic yield of maize plants (i.e. cob). Higher harvest index indicates better translocation of assimilates to cob Average mean of harvest index 35.8% was obtained. Both varieties showed significant differences in harvest index. Variety Arun-2 have highest harvest index (38.5%) as compared to Rampur composite (33.1%). There was no significant change observed due to different row spacing and interaction of row spacing and varieties had no significant effect on Harvest index.

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Table 2. Grain yield and yield attributes as affected by different maize varieties and row spacings

Treatments	Cob length (cm)	Cob circumference (cm)	Number of row per cob	Thousand grain weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index
Varieties							
Arun – 2	14.5b	12.0b	11.9b	262.7	2.9b	4.8b	38.5
Rampur composite	15.2a	12.5a	12.6a	273.2	3.5a	7.2a	33.1
LSD(0.05)	0.5	0.4	0.4	34.7	0.4	0.9	4.8
Row spacings							
Broadcast	13.5b	11.4c	11.7b	236.6b	2.5c	4.6b	36.9
45 cm x 25 cm	14.0b	12.0b	12.1ab	252.4b	3.2b	6.6a	33.2
60 cm x 25 cm	15.8a	12.6a	12.5a	290.3a	3.8a	7.0a	35.7
75 cm x 25 cm	15.9a	13.1a	12.7a	292.6a	3.5ab	5.8ab	37.6
LSD(0.05)	0.7	0.6	0.6	36.4	0.5	1.3	-
CV%	4.1	3.6	4.1	11	12.8	18	15.4
Mean	14.8	12.2	12.3	268	3.2	6	35.8

Treatments means followed by the same letter (s) within column are non-significantly different among each other at 5% level of significance. LSD= Least significant difference, and CV= Coefficient of variation

Economic Analysis

Cost of cultivation

Average cost associated with maize cultivation was found to be NRs. 66.6 thousands /ha. Cost of cultivation was insignificant with respect to variety, where cost NRs. 66.6 thousands /ha was found to be associated with cultivation of each variety. But row spacing significantly affect the cost of cultivation, lower the row spacing, higher was the cost of cultivation associated with it. So the highest cost of cultivation was for inter row spacing 45 cm × 25 cm (NRs. 68.2 thousands /ha) followed by row spacing 60 cm × 25 cm (NRs. 66.8 thousands /ha) and 75 cm × 25 cm (NRs. 66.0 thousands /ha) and least cost (NRs. 65.5 thousands /ha) was associated with production in broadcasting.

Gross return

Average gross return from sales of products and byproducts was found to be NRs. 113.5 thousands /ha. Varieties were found significant effect in gross income due to difference net biomass yield. Rampur Composite variety gave the highest return (NRs.124.1 thousands /ha) followed by Arun-2 (NRs. 103.0 thousands /ha). Row spacing also found significant effects in gross return. Row spacing of 60 cm × 25 cm gave the highest return (NRs. 133.3 thousands /ha) followed by 75 cm × 25 cm (NRs. 121.4 thousands /ha) and 45 cm × 25 cm (NRs.110.8 thousands /ha) and least return was obtained from broadcasting (NRs. 88.7 thousands /ha).

Net return

Average net income was found to be NRs. 46.9 thousands /ha and was significantly affected by varieties and Row spacing. Variety Rampur composite was found to give best net income (NRs. 57.5 thousands /ha) with respect to Arun-2 (NRs. 36.3 thousands /ha). Showing significant effect of row spacing on net income, row spacing of 60 c m× 25 cm gave higher net income (NRs. 66.5 thousands /ha) followed row spacing of 75 cm × 25 cm (NRs. 55.4

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thousands /ha) and 45 cm × 25 cm (NRs. 42.6 thousands /ha) and broadcasting was found to result in loss of NRs. 23.2 thousands /ha.

Table 3. Economics of production of different maize varieties sown under different row spacing

Treatments	Economic parameters (NRs./ha in thousands)			BC ratio
	Cost of cultivation	Gross Income	Net Income	
Varieties				
Arun-2	66.6	103.0b	36.3b	1.5b
Rampur Composite	66.6	124.1a	57.5a	1.9a
LSD(0.05)	0.8	12.7	12.7	0.2
Inter row spacing				
Broadcast	65.5d	88.7c	23.2c	1.3c
45 cm x 25 cm	68.2a	110.8b	42.6b	1.6b
60 cm x 25 cm	66.8b	133.3a	66.5a	2.0a
75 cm x 25 cm	66.0c	121.4ab	55.4ab	1.9ab
LSD(0.05)	0.10	18	18	0.3
CV%	0.001	12.8	13.1	12.3
Mean	66.6	113.5	46.9	1.7

Treatments means followed by the same letter (s) within column are non-significantly different among each other at 5% level of significance. LSD= Least significant difference, and CV= Coefficient of variation

Benefit cost ratio

Average B: C ratio was found to be 1.7 which signifies fairly beneficial cultivation practice. Varieties significantly affect B: C ratio. Rampur composite variety was found to result in higher B: C ratio (1.9) followed by arun-2 B: C ratio (1.5). Row spacing also have a significant effect on B: C ratio. Row spacing of 60 cm × 25 cm resulted in higher B:C ratio (2.0) followed by spacing 75 cm × 25cm (1.9) and 45 cm × 25 cm, B:C ratio (1.6) least B:C ratio was resulted by broadcasting (1.3) signifying higher cost of production than benefit

Table 4. Interaction effect of different maize varieties and row spacings on grain yield and yield attributing traits

Spacing	Varieties	CL	Ccir	NRPC	TGW	GY	SY	HI
Boardcasting	Arun-2	13	11.3	11.1	241.3	2.1	3.4	39.9
	Rampur Composite	14	11.4	12.4	231.9	3	5.9	33.9
45 cm x 25 cm	Arun-2	13.6	11.7	11.9	243.3	3	5.1	36.9
	Rampur Composite	14.4	12.2	12.4	261.5	3.4	8.1	29.5
60 cm x 25 cm	Arun-2	15.7	11.9	12.1	280.2	3.6	5.8	38.1
	Rampur Composite	16	13.2	12.8	300.4	4	8.1	33.2
75 cm x 25 cm	Arun-2	15.6	13	12.5	286.1	3.1	4.9	39.2
	Rampur Composite	16.3	13.2	12.9	299	3.8	6.8	36
CV (%)		4.1	3.6	4.1	11	12.8	18	15.4
Grand Mean		14.8	12.2	12.3	268	3.2	6	35.8

CL= cob length (cm), Ccir= cob circumference (cm), NRPC= no of row per cob, and TGW= thousand grain weight (g), GY= grain yield (t/ha), SY= stover yield (t/ha), HI= harvest index,

Interaction effect between varieties and inter row spacing was statistically non-significant for yield and yield attributes traits under consideration

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Table 5. Interaction effect of different maize varieties and row spacings on economics of maize

Spacing	Varieties	NRs./ha in thousands			
		CC	GI	NI	BC
Boardcasting	Arun-2	66.5	73.5	8	1.1
	Rampur Composite	66.5	103.8	38.3	1.6
45 cm x 25 cm	Arun-2	68.2	103.8	35.6	1.5
	Rampur Composite	68.2	117.8	49.6	1.7
60 cm x 25 cm	Arun-2	66.8	124.8	58	1.9
	Rampur Composite	66.8	141.7	74.9	2.1
75 cm x 25 cm	Arun-2	66	109.7	43.7	1.7
	Rampur Composite	66	133	67	2
CV (%)		0.01	12.8	13.1	12.3
Grand Mean		66.6	113.5	46.9	1.7

CC= Cost of cultivation, GI= gross income, NI= Net income and BC= benefit cost ratio.

CONCLUSION

The different spacing and varieties have significantly affected yield and yield of the components of maize. The highest maize yield and yield components was found under inter-row spacing 60×25 cm and Rampur composite variety. The implication of this study concluded that maize should be planted under spacing 60×25 cm to ensure maximum economic grain yield per production area. However, since, this study was focus on mere one season and one location; it needs further study for recommendation of specific spacing for specific variety.

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Authors contribution

A. Dhakal, D. Niraula, S. Bartaula, U. Panthi and M. Mahato helped in data recording. S. Koirala conducted the trial and recorded data, analyzed and wrote the final manuscript.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

REFERENCES

Abuzar, M.R., Sadoza, G.U., Balochm, S., Baloch, A.A., Shah, I.H., Javaid, T., & Hussain, N. (2011). Effect of pl.ant population densities on yield of maize. *The Journal of Animal and Plant Sciences, 21*(4), 692-695.

Bartaula, S., Panthi, U., Timilsena, K., Acharya, S.S., & Shrestha, J. (2019). Variability, heritability and genetic advance of maize (*Zea mays* L.) genotypes. *Research in Agriculture, Livestock and Fisheries, 6* (2), 163-169.

Carangal, V.R., Ali, S.M., Koble, A.F., & Rinke, E.H. (1971). Comparison of S1 with test cross evaluation for recurrent selection in maize. *Crop Science, 11*, 658-661.

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DOI: https://doi.org/10.3126/janr.v3i1.27174

Davi, C.M., Reddy, B.R., Reddy, P.M., & Reddy SCS. (1995). Effects on Nitrogen levels and plant density on yield and quality of JKHY-1 cotton. *Current Agriculture Research Journal*, *8*(3/4), 144-146.

Gurung, D.B., Bhandari, B., Shrestha, J., & Tripathi, M.P. (2018). Productivity of maize (*Zea mays* L.) as affected by varieties and sowing dates. *International Journal of Applied Biology*, *2*(2), 13-19.

IITA. (2001). Improved Maize Varieties for Sustainable Agriculture in Sub-Saharan Africa 1-16, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Iken, J.E., Anusa, A., & Obaloju, V.O. (2001). Nutrient Composition and Weight Evaluation of some newly Developed maize Varieties in Nigeria. *Journal of Food Technology, 7*, 25-28.

Krezel, R., & Sobkowicz, P. (1996). The effect of sowing rates and methods on winter triticale grown on light soil. Roczniki Nauk Rolniczych. Seria A Produkeja Roslinna, *111*(3/4), 69-78.

Lawson, H.M., & Topham, P.B. (1985). Competition between annual weeds and vining peas grown at a range of population densities: Effects on the weeds. *Weed Research Journal*, *25*, 221-229.

Luque, S.F., Cirilo, A.G., & Otegui, M.E. (2006). Genetic gains in grain yield and related physiological attributes in Argentine maize hybrids. *Field Crop Research*, *95*, 383-397.

MOAD. (2017). Statistical Information on Nepalese Agriculture. Ministry of Agricultural Development, Nepal.

Sangoi, L. (2001). Understanding plant density effects on maize growth and development: An important issue to maximize grain yield. *Ciencia Rural*, *31*(1), 159-168.

Shah, S., Khan, S., Muhammad, Z., Hayat, Y., & Arif, M. (2001). Effect of different row spacing and orientations on the performance of maize. *Sarhad Journa of Agriculture*. *17*(4), 515-518.

Sharma, H.P., Dhakal, K.H., Kharel, R., & Shrestha, J. (2016). Estimation of heterosis in yield and yield attributing traits in single cross hybrids of maize. *Journal of Maize Research and Development*, *2*(1), 123-132.

Sharma, R., Adhikari, P., Shrestha, J. & Acharya, B.P. (2019). Response of maize (*Zea mays* L.) hybrids to different levels of nitrogen. *Archives of Agriculture and Environmental Science*, *4*(3), 295-299,

Shrestha, J. (2019). P-Value: A true test of significance in agricultural research. Retrieved from *https://www.linkedin.com/pulse/p-value-test-significance-agricultural-research-jiban-shrestha/*

Shrestha, J., Subedi, S., Timsina, K.P., Gairhe, S., Kandel, M., & Subedi, M. (2019). Maize Research. New India Publishing Agency (NIPA), New Delhi-34, India.

Shrestha, J., Yadav, D.N., Amgain, L.P., & Sharma, J.P. (2018). Effects of nitrogen and plant density on maize (*Zea mays* L.) phenology and grain yield. *Current Agriculture Research Journal*, *6*(2), 175-182.

Zamir, M., Ahmad, A.H., Javeed, H.M.R., & Latif, T. (2011). Growth and yield behavior of two maize hybrids (*Zea mays* L.) towards different plant spacing. *Cercetări Agronomice în Moldova*, *14*(2), 3-40.