Journal of Agriculture and Natural Resources (2021) 4(2): 201-210
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

Research Article

Bridging yield gap of winter maize using improved agronomic management practices

Richa Devkota[1*], Prem Pandey[2], Tika Bahadur Karki[3], Santosh Marahatta[1] and Shrawan Kumar Sah[1]

[1]Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal
[2]Faculty of Agriculture, Far Western University, Tikapur, Kailali, Nepal
[3]Nepal Agricultural Research Council, Singhdurbar Plaza, Kathmandu, Nepal
*Correspondence: devkotaricha83@gmail.com
*ORCID: https://orcid.org/0000-0003-1501-7043
Received: June 15, 2020; Revised: October 25, 2020;
Accepted: December 20, 2020; Available online: January 01, 2021

ABSTRACT

Appropriate combinations of inputs determine the productivity of crops. A field experiment was carried out to evaluate the effect of different combinations of inputs on the yield of winter maize at National Maize Research Program (NMRP), Rampur, Chitwan. The experiment was laid out in randomized complete block design with four replications comprising of six treatments (T_1= Hybrid (H) + recommended doses of NPK (RD) + irrigation (I) + high density (HD) (83333 plant ha^{-1}) + improved weed management practice (IWMP), T_2=Open pollinated variety (OPV)+RD+I+HD+IWMP, T_3=OPV+ farmer's doses of NPK (FD)+I+HD+IWMP, T_4= OPV+FD+rainfed (R)+HD+IWMP, T_5=OPV+ FD+ R+low density (LD) (55555 plant ha^{-1}) + IWMP, T_6=OPV+FD+R+LD+ farmer's weed management practice (FWMP). The research result revealed significant variation on the grain yield among the different treatments. The highest grain yield (5357 kg ha^{-1}) was obtained when hybrid maize was grown with recommended dose of fertilizer, higher density, irrigation and improved weed management practices. This treatment was followed by replacement of OPV in the above treatment (4410.77 kg ha^{-1}). The decline in yield due to replacement of OPV from hybrid was 17.67 percent. The percent yield decline from full Package of practices (T_1) were 23.01, 47.81, 36.66 and 35.95 when input combinations OPV+FD+I+ HD+IWMP, OPV + FD+R+HD+IWMP, OPV+FD+R+LD+IWMP and OPV+FD+R+LD+ FWMP respectively were used.The contrast for grain yield between hybrid vs. OPV, RD vs. FD and Irrigated vs. Rainfed were significant. Therefore, present investigation showed hybrid maize, recommended dose of fertilizer and irrigation were the most important inputs for improving maize productivity in winter season in Chitwan like climatic condition.

Keywords: Hybrid maize, fertilizer dose, irrigation and yield

Correct citation: Devkota, R., Pandey, P., Karki, T.B., Marahatta, S., & Sah, S. K. (2021). Bridging yield gap of winter maize using improved agronomic management practices. Journal of Agriculture and Natural Resources, *4*(2), 201-210.
DOI: https://doi.org/10.3126/janr.v4i2.33772

INTRODUCTION

Maize (*Zea mays* L.) is the world's widely grown cereal and primary staple food crop in many developing countries. It is the second most important staple food crops both in terms of area and production after rice in Nepal. It is grown in about 0.9 million hectare land with 2.7 million tones of total production and 2.83 t ha^{-1} productivity (MoALD, 2019) and occupies

Journal of Agriculture and Natural Resources (2021) 4(2): 201-210
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

30.04% of the total cultivated land with share of 23.87% on the total cereal production in Nepal (MoAD, 2015). Maize cultivation is a way of life for most farmers in the hills of Nepal (Adhikari, 2000; Prasai *et al*., 2015).The demand of maize grains in the recent days is increasing due to increasing trend of poultry and livestock business along with increasing population. More than 86% of maize production has been used for human consumption in the hills and 80% of maize production in Terai is used for poultry and animal feed (Gurung *et al*., 2011). The farm level yield of maize (2.55 t ha^{-1}) is not satisfactory as compared to attainable yield (5.7 t ha^{-1}) in Nepal (MOAD, 2017; Karki *et al*., 2015; Shrestha *et al*., 2019).Although maize has a great yield potential yet its present average yield in Nepal (2.83 t ha^{-1}) is very low as compared to USA, China and Brazil (11.08, 6.11 and 5.61 t ha^{-1}) and even lower than the attainable yield. Among the different factors responsible for low yield were poor crop management practices namely imbalance or low use of fertilizer, lower plant density, unavailability of irrigation water, poor weed management and lack of location specific high yielding open pollinated varieties (OPVs) and hybrids. Most of the farmers in hilly area use local varieties instead of improved and hybrid varieties, which is the major causes of lower yield of maize. Similarly, the seed replacement rate is also low in maize (15.3%) in Nepal (SQCC, 2017) compared to 99% in Bangladesh (due to hybrids). Crop production can be doubled or even tripled with integrated crop management through improved germplasm, soil fertility management, early and appropriate weed control and efficient capture and utilization of water resources (Wang *et al*., 2014).

Although winter maize has high yield potential (> 6 t ha^{-1}) than main season (2-2.5 t ha^{-1}), raising a winter crop is a challenge due to lack of rainfall which is the major source of soil moisture for the resource poor farm families. Optimal irrigation application, throughout the growing season, is important for increasing maize productivity (Swelam & Atta, 2011). Fertilizer management is crucial for maize cultivation (Baral *et al*., 2015).Poor fertilizer management is another important constraits for maize cultivation in Nepal. Most of the farmers are not aware about information on crop management aspects particularly balanced use of fertilizers and management of maintaining optimum plant population per hectare. Lower plant population is one of the major yield reducing factors of maize in Nepal (Dawadi & Sah, 2012). Among the various biotic factors accountable for the low yield, weed infestation is also one of the major causes. Excessive growth of weeds in maize leads to 25 to 80% reduction in crop yield or sometimes to a complete crop failure (Chikoye & Ekeleme, 2003). There is a big yield gap in maize for both mid hills and Terai of Nepal. The experimental yield of OPV maize is 6.70 t ha^{-1} whereas attainable yield is 5.70 t ha^{-1}.The national average of maize is 2.55 t ha^{-1} (MoALD, 2018).So the yield gap at present is 3.15 t ha^{-1}. Similarly, the experimental yield of hybrid maize is 8.15 tha^{-1} and attainable yield is 7.27 t ha^{-1}, so the actual yield gap is 4.72 t ha^{-1} (Ghimire *et al*., 2016). If we narrow down the yield gaps in both OPVs and hybrids the demand for grains and feeds will easily be met and fulfilled. Thus, the focus should be directed towards narrowing of gaps through increasing access of improved seeds to the farmers and improved crop management practices.

Therefore, the present research was conducted to evaluate the influence of different production factors on growth and productivity and to analyze the yield gap as influenced by the different factors of production on maize during winter season in Rampur,Chitwan.

Journal of Agriculture and Natural Resources (2021) 4(2): 201-210
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

MATERIALS AND METHODS

Description of experimental site

A field research was conducted at National Maize Research Program, (NMRP) Rampur, Chitwan during the winter season from October 2017 to March 2018. The experimental site is situated in Central terai of Nepal which lies at $27^0 37'$ North latitude and $84^0 25'$ East longitude with the elevation of 256 masl (Thapa &Dangol, 1988).The soil of the experiment plot was sandy loam with pH(4.9), OM(3.53%), N(0.26%), P_2O_5(663.26kgha^{-1})and K_2O(145.15kgha^{-1})(NMRP 2017/18).

Climatic conditions during experimentation

Fortnightly, average data on different weather parameters i.e., maximum and minimum temperature, total rainfall, and relative humidity, was recorded from the meteorological station of NMRP during the maize growing season and is presented in Figure 1.

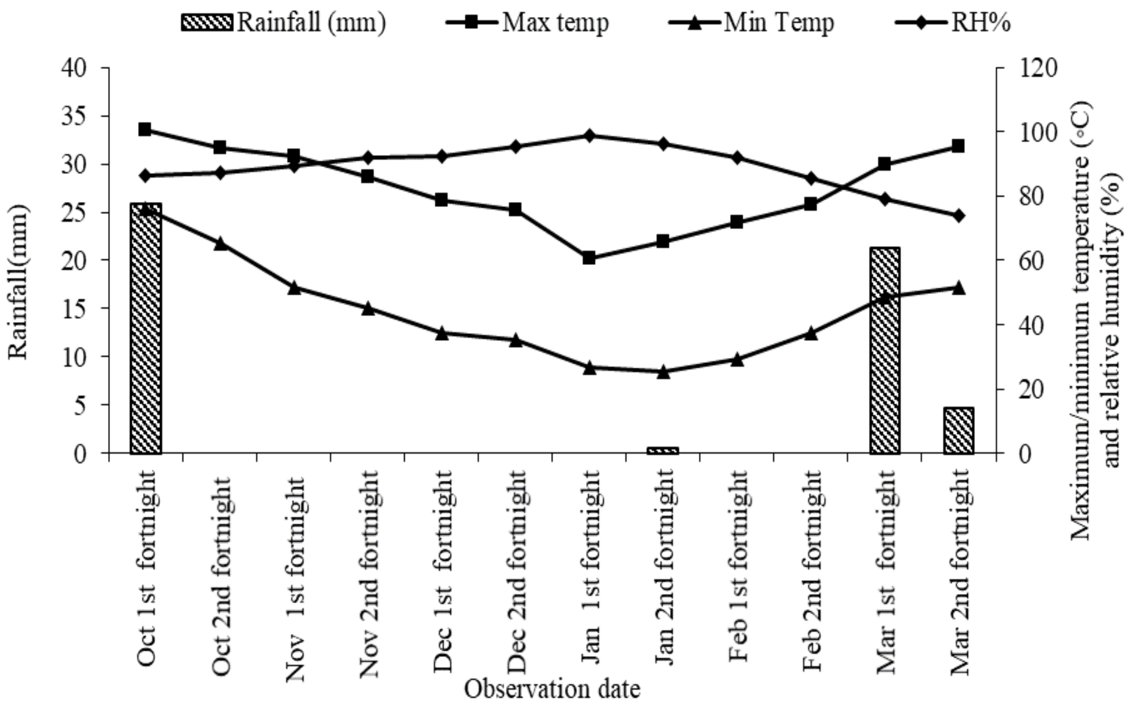

Figure 1: Weather condition during the course of experimentation at NMRP, Rampur, Chitwan, 2017/18

Treatment details

The details of experiment are listed in the following Table 1.
. m

Journal of Agriculture and Natural Resources (2021) 4(2): 201-210
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

Table1: Treatment description of the experiment at NMRP, Rampur, Chitwan, 2017/18

Treatment symbol	Full form of symbol	Detail of treatment used in experiment
H	Hybrid	Rampur hybrid 4(RML32/RML17)
OPV	Open pollinated variety	Rampur composite
RD	Recommended dose of nutrients	120:60:40 NPK kg ha^{-1}
FD	Farmer's dose of nutrients	70:30:20 NPK kg ha^{-1}
I	Irrigated	Three times irrigated (emergence, knee high and tasseling)
R	Rainfed	No irrigation given
HD	High density	60×20 (83333 plants ha^{-1})
LD	Low density	60×30 (55555 plants ha^{-1})
IWMP	Improved weed management practice	Atrazine(0.75 kg a.i ha^{-1}) +Pendimethalin (0.5 kg a.i ha^{-1}) tank mix followed by one hand weeding at 30 DAS
FWMP	Farmer's weed management practice	Two hand weeding, 30 DAS and 45 DAS

Table 2: Treatment combinations of the experiment at NMRP, Rampur, Chitwan, 2017/18

Treatments	Treatment details
T_1	H+ RD+I+HD+IWMP
T_2	OPV+RD +I+HD+IWMP
T_3	OPV+ FD+I+HD+IWMP
T_4	OPV+FD+R+HD+IWMP
T_5	OPV+FD+R+LD+IWMP
T_6	OPV+FD+R+LD+FWMP

Experimental details

Experiment was laid out in Randomized Complete Block Design (RCBD) consisting six treatments with four replications. Two cultivars, Rampur hybrid 4 and Rampur Composite was planted with plot size of 30m^2 (6m x 5m) at the spacing of of 60cm×20cm (high density) and 60cm×30cm (low density) on 12th October 2017. Field was fertilized with 120:60:40NPK kg ha^{-1} and 70:30:20 NPK kg ha^{-1} through urea, DAP and MOP. Nitrogen was applied in 3 split doses i.e. half at sowing and remaining at knee high stage and tasseling stage whereas full dose of phosphorous and potash were applied as basal dose at final land preparation. Single plant per hill was maintained by thinning extra plants on 30 DAS. Three irrigations were provided at different time interval i.e at emergence, knee high stage and tasseling stage. At the same time recommended dose of urea was also applied. Weed control method was used according to treatments. In case of farmer's practice of weed control two hand weeding were done. Similarly, in other treatments pre emergence herbicides (Atrazine and Pendimethalin) were applied as per recommended dose followed by one hand weeding at 30DAS. Harvesting of maize was done from net plot area of 15 m^2 of 5 rows from each plot manually with the help of sickles on 27th March 2018.

Data analysis

Grain yield (t/ha) at 15% moisture content was calculated using fresh ear weight with the help of the formula adopted by Carangal *et al*. (1971) and Shrestha *et al*. (2018). R Studio was used for data analysis and mean was separated at 5% level of significance (Obi, 1986; Shrestha, 2019). Data was analyzed by using GENSTAT (version 14th edition; VSN International, Hemel Hempstead, UK)

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

RESULTS AND DISCUSSION

Yield attributes

Number of plants per ha, number of ear per ha and number of cobs per plant was found higher in T_1 (H+RD+I+HD+IWMP) as stated in Table 3. Irrigation and density showed highly significant effect on plant population. The irrigation significantly improved the plant establishment thus the final number of plants per hectare was also higher in the irrigated treatments as compared to rainfed treatment. Number of cobs harvested were significantly ($P<0.001$) influenced by genotype, fertilizer dose and irrigation. The number of cobs harvested per hectare from Rampur hybrid 4 was significantly higher than Rampur composite variety. This might be due to genetic make up of the cultivar. More number of cobs per hectare was found in recommended fertilizer dose than in farmer's dose of fertilizer.

Our result are in line with (Shrestha, 2018) who found that the application of higher nitrogen dose (200 kg N per ha) gave the highest number of cobs per plant. These results happened might be due to development of large leaf area and accumulation of substantial amounts of dry matter in the corns and kernels under optimum fertilizer level. With greater fertilizer doses, the yield increasing effect of irrigation is also greater. Thus,obtained higher number of cobs in irrigated condition.

The effect of different treatments on the barrenness percentage was found significant (Table 3). T_4 produced the highest (5.73%) barrenness percentage and T_2 produced the lowest (3.15%) barrenness percentage which was statistically similar with other treatments. Variation was significant due to irrigation and fertilizer dose on barrenness percentage. Results showed that barren percentage was higher in high plant density in rainfed condition. The high barrenness percentage at high densities was due to the absence of the usual sink for the assimilate supply and limiting optimum conversion of light energy to grain in maize grown at high plant densities which inhibited the plants to produce viable ears. Similarly, plants become taller and weaker at higher densities which lead to higher lodging.

Gardner *et al.* (1985) also reported the increased lodging with increasing plant density. Barren percentage was higher in rainfed condition than at irrigated condition. Water supply also plays a significant role in the utilization of fertilizer active substances especially that of nitrogen. Water deficiency in seed filling stage results in dry matter accumulation decrease and simultaneously shorten seed improvement period (Nesmith & Ritchie, 1992). Barrenness percentage was also significantly influenced by fertilizer dose. Gungula *et al.* (2007) reported that there will be more synchrony in flowering with higher nitrogen, thus reducing the rate of barrenness during grain filling period.

Journal of Agriculture and Natural Resources (2021) 4(2): 201-210
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

Table 3: Yield attributes of maize as influenced by agronomic management practices during winter at NMRP, Rampur, Chitwan, Nepal, 2017/18

Treatments	Number of plant ha^{-1}	Number of ear ha^{-1}	Number of cobs $plant^{-1}$	Number of kernel row cob^{-1}	Number of kernels row^{-1}	Thousand kernels weight (g)	Barrenness (%)
H+RD+I+HD+IWMP)	79833.33^{a}	90000^{a}	1.12^{a}	11.45^{b}	26.67	265.50	3.31^{b}(10.85^{b})
OPV+RD+I+HD+IWMP)	77666.67^{a}	64166.67^{bc}	0.82^{b}	13.40^{a}	23.51	301.75	3.15^{b}(10.52^{b})
OPV+FD+I+HD+IWMP)	75666.67^{a}	64666.67^{b}	0.85^{b}	13.45^{a}	22.67	300.25	3.48^{b}(12.11^{b})
OPV+FD+R+HD+IWMP)	78166.67^{a}	50000^{d}	0.63^{c}	13.25^{a}	23.78	276.50	5.73^{a}(34.22^{a})
OPV+FD+R+LD+IWMP)	55555.56^{b}	51909.72^{bcd}	0.93^{b}	13.41^{a}	22.96	305.98	4.00^{b}(15.93^{b})
OPV+FD+R+LD+FWMP)	55381.94^{b}	50868.06^{cd}	0.91^{b}	13.75^{a}	22.87	302.50	4.06^{b}(16.59^{b})
Grand mean	70378.47	61935.19	0.88	13.11	23.74	292.08	3.95
SEm (±)	3302.87	8091.70	0.104	0.54	1.76	27.52	0.96
LSD (=0.05)	4977.96	12195.51	0.156	0.82	Ns	Ns	1.46
CV, %	4.69	13.06	11.78	4.14	7.43	9.42	24.56
F-test							
Hybrid vs. OPV	Ns	***	***	***	***	*	ns
RD vs. FD	*	***	Ns	**	*	Ns	*
Irrigated vs. rainfed	***	***	Ns	ns	Ns	Ns	**
HD vs. LD	***	*	Ns	ns	Ns	Ns	Ns
IWMP vs. FWMP	**	Ns	Ns	ns	Ns	Ns	Ns

*Note: ns, non-significance; *, significant at 0.05 level of significance; **, significant at 0.01 level of significance;DAS, days after sowing; OPV, open pollinated variety (Rampur Composite); hybrid, Rampur hybrid 4; RD, recommended dose of fertilizer (120:60:40 kg ha^{-1} NPK); FD, farmer dose of fertilizer (70:30:20 kg ha^{-1} NPK); HD (high density; 60 cm x 20 cm); LD (low density; 60 cm x 30 cm), IWMP (Atrazine @ 0.75 kg a.i. ha^{-1} + Pendimethalin @ 0.5 kg a.i. ha^{-1} tank mix followed by hand weeding), FWMP(farmer practice; two hand weeding). Same letter(s) within column indicates the non-significant difference on Duncan's Multiple Range Test at 0.05 level of significance*

Yield, stover yield and harvest index

Different treatments exerted significant influences on the grain yield of maize. The highest grain yield (5357.13 kg ha^{-1}) was obtained under T_1 and the lowest (2795.63 kg ha^{-1}) was obtained under T_4 (Table 4). The grain yield varied significantly ($p<0.001$) due to genotype, fertilizer dose and irrigation. Yield of Rampur hybrid 4 was significantly higher than Rampur composite. It can be concluded from this result that hybrids are higher yielding than the open pollinated varieties of maize. The hybrids have been characterized to have high yield potentials (Tollenaar & Lee, 2006) due mainly to higher assimilatory surfaces and high leaf angle that could facilitate diffusion of light into the lower portion of the canopy (Duncan *et al*., 1967). Abayomi *et al.* (2006) reported that the yield advantage observed in the hybrid maize could be linked to their higher leaf growth, leaf area duration and effective leaf area than the OPV.

The research findings indicated that grain yield increased with increase in fertilizer dose. Our results is in agreement with (Shrestha *et al*., 2018), who reported that grain yield increase with increasing level of N (200 kg N ha^{-1}) .Grain yield was found higher when higher level of phosphorous was applied. Our results are in line with those of Ahmad *et al*. (2007)**,** who reported more grain yield with higher rate of P_2O_5 applied. Similar to our results, Saleem *et al*. (2011) also reported higher grain yield with the increase in K_2O level.

The rainfed maize measured the lowest grain yield whereas yield increased in response to irrigation (Table 4). The lower grain yield of maize under water stress may be primarily due

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

to reducing CO_2 assimilation area, net assimilation rate, leaf number and total leaf area, and yield components (ear size, number of grains per ear, and grain mass). The increased grain yields of corn was mainly due to the adequate moisture availability and increased uptake of nutrients throughout the crop growth stages, having beneficial effect on yield components. Our result is in line with Ertek and Kara, (2013),who reported higher grain yield due to irrigation which might be accounted to their favourable influence on the crop growth and yield attributes.

Stover yield was significantly affected by variety, fertilizer dose, irrigation and plant density (Table 4). Higher stover yield was obtained when fertilizer was applied @ 120: 60:40 kg N, P_2O_5 and K_2O ha^{-1}. Singh *et al*. (2000) indicated that grain and stover yield increased with the increase in nitrogen level from 0-200 kg ha^{-1}. Increased in stover yield at higher P_2O_5 level indicated that applying more P_2O_5 increased availability of P_2O_5. Enhancement in stover yield with the increased K_2O level might be attributed to the increase in the height of maize plants. There was an increment of biomass yield parallel with an increase in planting density rate since there is the presence of more number of stands per unit area, improved translocation of dry matter accumulation, efficient N uptake and presence of increased competition for light. Stover yield was found higher in irrigated condition than that of rainfed condition, since irrigation (soil moisture) increases the fertilizer use efficiency.

Table 4: Grain yield, stover yield and Harvest index of maize as influenced by agronomic management practices during winter at NMRP, Rampur, Chitwan, Nepal, 2017/18

Treatments	Grain yield (kg ha^{-1})	Stover (kg ha^{-1})	HI
H+RD+I+HD+IWMP	5357.13^{a}	5144.94^{a}	0.44
OPV+RD+I+HD+IWMP	4410.77^{b}	4527.97^{ab}	0.41
OPV+FD+I+HD+IWMP	4124.32^{bc}	4986.37^{a}	0.38
OPV+FD+R+HD+IWMP	2795.63^{d}	3771.61^{b}	0.35
OPV+FD+R+LD+IWMP	3393.04^{cd}	4079.97^{ab}	0.39
OPV+FD+R+LD+FWMP	3430.79^{bcd}	3654.20^{b}	0.41
Grand mean	3918.61	4360.84	0.403
SEm (±)	593.69	695.09	0.05
LSD (=0.05)	894.79	1047.624	Ns
CV, %	15.15	15.93	12.66
F-test			
Hybrid vs. OPV	***	*	Ns
RD vs. FD	***	*	Ns
Irrigated vs rainfed	***	**	Ns
HD vs. LD	Ns	*	Ns
IWMP vs. FWMP	Ns	Ns	Ns

*Note: ns, non-significance; *, significant at 0.05 level of significance; **, significant at 0.01 level of significance; DAS, days after sowing; OPV, open pollinated variety (Rampur Composite); hybrid, Rampur hybrid 4; RD, recommended dose of fertilizer (120:60:40 kg ha^{-1} NPK); FD, farmer dose of fertilizer (70:30:20 kg ha^{-1} NPK); HD (high density; 60 cm x 20 cm); LD (low density; 60 cm x 30 cm), IWMP (Atrazine @ 0.75 kg a.i. ha^{-1} + Pendimethalin @ 0.5 kg a.i. ha^{-1} tank mix followed by hand weeding), FWMP(farmer practice; two hand weeding). Same letter(s) within column indicates the non-significant difference on Duncan's Multiple Range Test at 0.05 level of significance*

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

Table 5: Yield gap and percent yield decline between full package of practices and different inputs combination in winter maize at NMRP, Rampur, Chitwan,Nepal, 2017/18

Treatments	Yield ($kgha^{-1}$)	Yield gap ($kgha^{-1}$)	% decline in yield over pops(Package of practices)
Best pops(H+RD+I+HD+IWMP)	5357.12	0	0
Best factor 1(OPV+RD+I+HD+IWMP)	4410.77	946.35	17.67
Best factor 2(OPV+FD+I+HD+IWMP)	4124.32	1232.80	23.01
Best factor 3(OPV+FD+R+HD+IWMP)	2795.63	2561.49	47.81
Best factor 4(OPV+FD+R+LD+IWMP)	3393.04	1964.08	36.66
Best factor 5(OPV+FD+R+LD+FWMP)	3430.79	1926.33	35.95

Based on the best package of practices, the yield gap was calculated and presented in Table 5. Only replacing the hybrid by OPV, the grain yield was decreased by 17.67%, while, replacing the fertilizer dose by farmer's dose resulted the further decrease of 23.01%.When OPV planted with lower fertility management on rainfed condition results the yield gap of 24.80% as compared to the irrigated condition(47.81%). Decreasing the plant density based on T_4(OPV+FD+R+HD+IWMP) improve the yield by11.15% (36.66% decreased as compared to $T_{1,}$(H+RD+I+HD+IWMP). By adopting T_6(OPV+FD+R+LD+FWMP) with farmer's weed management practices and OPV with rainfed, low fertilizer doses and low density decreased the yield by 35.95% as compared to best treatment.

CONCLUSION

The combination of different inputs showed wide variation in the productivity of winter maize. Hybrid maize, recommended dose of fertilizer (120:60:40 NPK kg ha^{-1}) and irrigation (at emergence, Knee high stage and tasseling stage) were the three most important inputs for increasing productivity of winter maize in Chitwan like climatic condition. Hence yield gap of maize crop can be narrowed using improved agronomic practices.

ACKNOWLEDGMENT

The author is highly grateful to National Maize Research Program (NMRP), Rampur, Chitwan, Nepal for providing field and inputs during conduction of this experiment. Authors would like to acknowledge Dr. Lal Pd. Amgain for his erudite suggestions regarding manuscript development and shaping.

Authors' contributions

R. Devkota planned, designed and conducted this experiment and wrote the initial draft of this manuscript. P. Pandey helped in collecting data and writing the final manuscript. S. Marahatta guided to conduct the experiment and helped in data analysis, T.B. Karki and S.K. Sah made revision of initial draft of the manuscript and suggested during and throughout the experiment conduction.

Conflict of interest

The author declares no conflicts of interest regarding publication of this manuscript.

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

REFERENCES

Abayomi, L. A., Terry, L. A., White, S. F., & Warner, P. J. (2006). Development of a disposable pyruvate biosensor to determine pungency in onions (Allium cepa L.). *Biosensors and Bioelectronics*, *21*(11), 2176-217.

Adhikari, K. (2000). Maize Research Strategy in Nepal. In: Adhikari K. and B. Batsa (eds). Proceedings of 22nd National Summer Crops Workshop, Rampur, Chitwan, Nepal.National Maize Research Program.Pp 25-36.

Ahmad, M., Hussain, N., Jan, A., Ahmad, K., & Hussain, S. (2007). Response of maize to phosphorus levels and plant density, *Sarhad Journal of Agriculture*, *23*(1), 69-74

Baral, B. R., Adhikari, P., & Shrestha, J. (2015).Growth and yield response of hybrid maize (*Zea mays* L.) to phosphorus levels in sandy loam soil of Chitwan valley, Nepal. *International Journal of Environment*, *4*(2), 147-156

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

Chikoye, D., & Ekeleme, F. (2003).Cover crops for cogongrass (*Imperata cylindrica*) management and effects on subsequent corn yield, *Weed Science*, *51*(5), 792-797

Dawadi, D. R., & Sah, S. K. (2012). Growth and yield of hybrid maize (*Zea mays* L.) in relation to planting density and nitrogen levels during winter season in Nepal,*Tropical Agriculture Research*, *23*(3), *218-227.*

Duncan, W. G. R. S., Loomis, R., Williams, W., & Hanau, R. (1967).A model for simulating photosynthesis in plant communities, *Hilgardia*, *38*(4), 181-205

Ertek, A., & Kara, B. (2013).Yield and quality of sweet corn under deficit irrigation, *Agricultural water management*, *129*, 138-144

Ertek, A., & Kara, B. (2013).Yield and quality of sweet corn under deficit irrigation, *Agricultural water management*, *129*, 138-144

Gardner, F. P., Pearce, R. B., & Mitchell, R. L. (1985). Physiology of Crop Plants 1st (Ed.)The Iowa State University Press, Ames. *Iowa, USA.* pp. 66-70.

Ghimire, S., Sherchan, D. P., Andersen, P., Pokhrel, C., Ghimire, S., & Khanal, D. (2016).Effect of variety and practice of cultivation on yield of spring Maize in Terai of Nepal, *Agrotechnol*, *5*(144), 2

Gungula, D. T., Togun, A. O., & Kling, J. G. (2007).The effects of nitrogen rates on phenology and yield components of early maturing maize cultivars, *Global Journal of Pure and Applied Sciences*, *13*(3), 319-324.

Gurung, D. B., KC, D., Ortiz Ferrara, G., Gadal, N., Pokhrel, S., Bhandari, D. R., & Tripathi, M. (2011). Maize Value Chians in Nepal.*11th Asian Maize Confernece held at China on*, 7-11.

Karki, T. B., Shrestha, J., Achhami, B. B., & KC, G. (2015). Status and prospects of maize research in Nepal. Journal of Maize Research and Development, 1(2), 1-9.

MoAD (2015). Statistical information on Nepalese agriculture 2014/15 (2071/072), Government of Nepal, Ministry of Agricultural Development, agribusiness promotion and Statistics Division, Singhadurbar, Kathmandu, Nepal.

MoALD (2019). Statistical information on Nepalese agriculture 2070/71.Agribusiness Promotion and Statistics Division, Ministry of Agriculture Development, Kathmandu,Nepal

MoALD. (2017). Statistical information on nepalese agriculture. Government of Nepal. Ministry of Agriculture and Livestock Development, Singha Durbar, Kathmandu, Nepal.

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v4i2.33772

NeSmith, D. S., & Ritchie, J. T. (1992). Maize (*Zea mays* L.) response to a severe soil water-deficit during grain-filling, *Field Crops Research*, *29*(1), 23-35.

Obi, I. U. 1986, Statistical methods of detecting differences between treatment means, SNAAP press limited, Enugu, Nigeria, 45p.

Prasai, H., Kushwaha, U., Joshi, B., & Shrestha, J. (2015). Performance evaluation of early maize genotypes in far western hills of Nepal. *Journal of Maize Research and Development*, *1*(1), 106-111. https://doi.org/10.3126/jmrd.v1i1.14248

Saleem, A., Javed, H.I., Saleem, R., Ansar, M., & Zia, M.A. (2011). Effect of split application of potash fertilizer on maize and sorghum in Pakistan.*Pakistan JAgric Res*, 24(1-4), 31-34

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., Gurung, D.B., Koirala, K.B., & Rijal, T.R. (2019). Performance evaluation of maize in Jumla district of Nepal: from yielding perspective. *International Journal of Applied Biology*, *3*(2), 35-45.

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

Singh, D. P., Rana, N. S., & Singh, R. P. (2000). Growth and yield of winter maize (*Zea mays*) as influenced by intercrops and nitrogen application, *Indian Journal of Agronomy*, *45*(3), 515-519.

SQCC (Seed Quality Control Centre) .(2017). MoAC/Seed Quality Control Center, Harihar Bhawan, Lalitpur, Nepal

Swelam, A., & Atta, Y. (2011).New approach of farm management under surface irrigation to improve water saving and productivity, *New Horizons in Sci. Technol*, *1*, 76-83

Thapa, R. B., & Dangol, D. R. (1988). A preliminary survey of weed flora at IAAS and its vicinity. *IAAS Research Report (1985-1991). Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal*, 59-65.

Tollenaar, M., & Lee, E. A. (2006). Physiological dissection of grain yield in maize by examining genetic improvement and heterosis, *Maydica*, *51*(2), 399-408

Wang, J., Wang, E., Yin, H., Feng, L., & Zhang, J. (2014). Declining yield potential and shrinking yield gaps of maize in the North China Plain. *Agricultural and forest Meteorology*, *195*, 89-101.