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EVALUATION OF GRAIN YIELD, YIELD ATTRIBUTES AND ECONOMIC PROFITABILITY OF MAIZE VARIETIES UNDER INTERCROPPING WITH COWPEA IN NEPAL

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ABSTRACT

Cereal-legume intercropping has popularly been practice in mid-hill of Nepal and it has great potentiality and profitability to farming community. Several intercropping studies have been done under field conditions, but species interaction driven varieties has hardly been tested in field condition. A research was carried out at Agriculture Knowledge Center, Ghyalchowk, Gorkha in 2021/22 to investigate the yield performance of maize varieties under maize-cowpea intercropping. Five maize varieties [*viz.*, Arun-2, Rampur composite, Rampur hybrid-10, Rasi-3033 hybrid] were planted in randomized complete block design lay-out to compare the performance of maize varieties in sole and intercrop with cowpea. Field experiment showed the open pollinated varieties produced significantly lower grain yield in intercropping, mainly due to lower number of kernel rows, number of kernels and test weight. The plant height, number of kernel rows, number of kernels and test weight were statistically at par in Rasi-3033 hybrid and Rampur hybrid-10 under sole and intercropping system, and their grain yield was also not greatly changed in intercropping. The major yield component for restricting yield in intercrop was number of kernels/row with higher coefficient of determination. However, test weight was the most important limiting factor in sole. The present study showed the hybrid based intercropping has higher maize-equivalent yield, land equivalent ratio and benefit-cost ratio. In overall, hybrids varieties yields outstanding than OPV's and also demonstrated economically profitable, thus inclusion of hybrids is a good approach for fosteringproductivity and profitability of maize-legume intercropping in farmer's field.

Key words: Hybrids, Intercropping, Mid-hill, test weight, Kernel number, Economic profitability

Introduction

Maize (*Zea mays* L.) is the predominant agronomical crop in hilly region of Nepaland it is mainly used as food and animal fodder. It is entirely the staple food combineapproximately half of food by weight (Ransom *et al.*, 2003), and shares about 23% to the National GDP and generates employment formajority of active population (*i.e.*, >60%) (MOALD, 2020). KC *et al.*, (2011, 2015) reported the limited access toquality improved seed, fertilizer, shortage in labor, fewprivate seed dealers, etc. assignificant challenges in maize seed production and trade in the hilly region of Nepal. The expansion of maize cultivated area in hilly region is limited by either too steep land of non-cropped area for sustainable production or is protected forest area (Ransom *et al.*, 2003). Farmers practices maize-legume intercropping in the mid-and high-hills of the country (Raut *et al.*, 2011). The food production stability, soil N sequestration and production potentiality strengthen of cereal crops canbe achieved through cropping systems diversity and improved supply of N by legume N_2 fixation (Maskey *et al.*, 2001; Jansen *et al.*, 2020). Dual-purpose legumes arealluring smallholder farmers who practice integrated crop-livestock systems for food and feed production (Rao and Mathuva, 2000).

Intercropping represents thegrowing of multiple crops together in one field during the growing season to promote the interaction among different crops (Habineza *et al*., 2017). Smallholder farmers almost utilize cereal-legumes cropping system (Rao and Mathuva, 2000). In addition to provide high returns per unit area, intercropping assures return from field, reduce soil erosion, weeds and insect infestation and cause efficient utilization of farm labour than sole crop. In addition, intercropping providesseveral socio-economic, biological and ecological benefitsthan mono-cropping (Mohammed *et al*., 2008). Moreover, intercropping with legumes reduce weed infestation and nutrient leaching due to improved soil coverage (Mucheru-Muna *et al*., 2010). Owing to its nitrogen fixing ability, legumes not only minimize the competition with maize componentbut also preserve soil fertility (Hiebsch and McCollum, 1987).

Results of Dahmardeh and Rigi (2013) indicate that maize-green gram intercropping can enlarge ground coverage in cropping system in comparison to sole maize, minimized water evaporation, maintenance of soil moisture and raise soil fertility leading to upsurge crop yield. A field trial conducted by Thapa (2014) in Dadeldhura, Nepal summarized that intercropping was advantageous for resource and land utilization. Eventhough the cowpea and soybean yield were drastically reduced in intercropping, the grain and stover dry matter yield of maize was not affected by cropping pattern. Also, intercropping system was found economically advantageous. Compared to sole, intercrops produced 1/3rd more gross incomes, whilst using only 77% land by increased land equivalent ratio (LER) (Alemayehu *et al*., 2017, 2018; Nassary *et al*., 2020; Bitew *et al*., 2021). Moreover, an intercropping experiment between maize-legume carried by Wei (2016) in Dadeldhura, Nepal also highlighted that intercropping had economic, biological and ecological benefits over monocropping. Yang *et al*., (2018) reported that different varieties of maize expressed different performance in intercropping. Gupta *et al*., (2019) observed variation on plant height and nutrition content of maize varieties in maize-cowpea intercropping. Similarly, Li *et al*., (2022) found significant variation in plant height, dry matter production, chemical composition and silage quality among the four forage varieties of maize (namely Rongyu Silage No. 1, Yayu 04889, Demeiya No. 1 & Zhenghong 505) in Ganzi, China.

Previous studies were done using a single variety of main and component cropto judge benefits of intercropping to yield and economic productivity. However, information on performance of different varieties of maize for interspecific competition and tolerability to maintain yield and yield components in intercropping are studied poorly. Thus, the present study was designed to investigate the yield performance of maize varieties under maize-cowpeaintercropping, therefore acquire maize varieties suitable for intercropping with cowpea in mid-hills of Nepal.

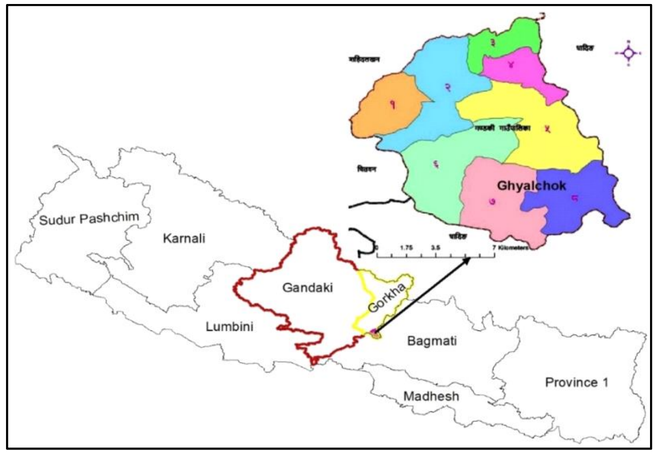

Fig. 1: Location of research site.

Materials and Methods

Experimental site

The experiment was done on the research field of Agriculture Knowledge Center (AKC), Ghyalchok, Gorkha, Nepal during post-rainy season of 2021/22. The area is located between 27.81 N latitude and 84.74 E longitude with an elevation of 601m above sea level. The location is presented in the following Fig. 1.

The Gorkhahas humid subtropical climate with dry winters. The Ghyalchok area has on an average 23.14°C maximum temperature and 7.67°C minimum temperature. On average, the mercury reached upto 28.62°C in summer and down to -2.39°C in winter. It receives on an average 1054.90 mm total annual rainfall. From September to March (*i.e.*, in growing season) the average maximum temperature remained 20.09°C and average minimum temperature was 2.54°C (Fig. 2). In Gorkha, upland soil was neutral (pH = 6.62), medium organic matter (OM = 3.52%), medium total nitrogen (N =

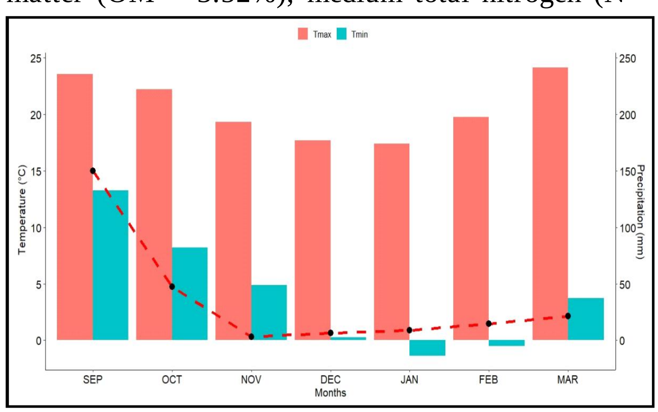

Fig. 2: Weather variation during cropping season (September, 2021-March, 2022).

Table 1: The treatment combination used in field experiment in winter, 2021/22.

Treatment No.	Treatment symbol	Treatment details	Cropping system
T1	A2	Arun-2	Sole
T2	RC	Rampur composite	Sole
T3	RH10	Rampur hybrid-10	Sole
T4	R3033	Rasi-3033 hybrid	Sole
T5	A2+C	Arun-2 + Cowpea	Intercrop (1:1)
T6	RC+C	Rampur composite + Cowpea	Intercrop (1:1)
T7	RH10+C	Rampur hybrid-10 + Cowpea	Intercrop (1:1)
T8	R3033+C	Rasi-3033 hybrid + Cowpea	Intercrop (1:1)
T9	C	Cowpea	Sole

0.108%), high available phosphorus (P = 93.67 kg/ha) and low available potassium (K = 36.49 kg/ha) (Shrestha *et al.*, 2018).

Field experiment

The experiment was done in single factorial randomized complete block design (RCBD) consisting of nine treatments and each treatment was replicated thrice. The four maize varieties (*viz.* Arun-2, Rampur composite, Rampur hybrid-10 and Rasi-3033 hybrid) and a cowpea variety (*viz.* Surya) and their intercropping combination were used in the treatments (Table 1). The treatments were assigned randomly in each experimental plot adopting lottery method of randomization.

Each individual plot size was 15.12m^2 with row length of 4.2m and breadth 3.6m. The seeds of maize were dropped manually in rows with spacing 60×30cm in each sole and intercrop plot. The net harvestable area for study was 7.56m^2 consisting of three rows of 4.2m length. In cowpea, seeds were sown by hand in rows with spacing 45×15cm in sole, so there were eight rows in each plot. In intercrop plot, cowpea was sown in middle of two maize rows in 1:1 alternate fashion, thus maintained five cowpea rows in each intercropped plot (Fig. 3). Two seeds per hill was applied at 5cm depth of row for both maize and cowpea on 24 September 2021. The FYM @10t/ha, NPK 120:60:40 for maize and 20:60:60 for cowpea were applied. Full dose of FYM, phosphorus and potash and half dose of nitrogen were applied as basal during final land preparation in maize. Remaining nitrogen dose was split in two equal half and one half was applied during knee high stage and another half during tasseling stage. In cowpea, all the doses of NPK were applied as basal dose. Two irrigation at knee high and silking stage of maize were applied. Weeding, earthing-up and plant protection practices were done and crop was harvested as per the maturity of varieties.

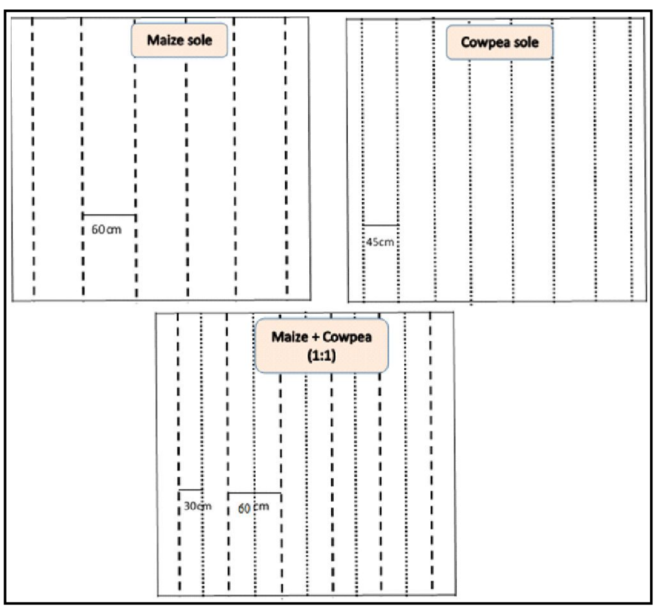

Fig. 3: Planting pattern for different cropping system.

Data collection

Plant height (from the soil surface to the base of tassel) was recorded based on observations of five representative sample plants randomly selected from central three rows of the plots. Manual harvesting of the plants was performed from central three rows (4.2m×1.8m = 7.56m^2) excluding border rows. Then all maize cobs were air dried for 7 days and weighed to take cob weight. After that,total five randomly selected sample cobs were taken for counting number of kernel rows and number of kernels. After manual threshed, a subsample of 1000 kernels were taken randomly, weighed and recorded as test weight (g). The moisture percentage in the grain was estimated with a moisture tester (Agra Tronix MT-16 grain moisture) and the grain yield(t/ha) was estimated by using the following formula.

$$\text{Grain yield}\left(\frac{t}{ha}\right)=\left[\frac{\textit{Plot yield (kg)}}{\textit{Net harvested area } (m^2)}\times\frac{(100 - \textit{recorded moisture})}{(100 - \textit{adjusted moisture})}\times\frac{10{,}000}{1000}\right]$$

Grain moisture was adjusted to 15% and the net harvested area was in m^2. In the equation, area (m^2) was converted to hectare by multiplying with 10,000 and yield (kg) into a metric ton by multiplying with 1000.

Maize equivalent yield (MEY)

The yield of each crop was turned into equivalent yield by aligning the prices of each crops accordingly (Anjeneyulu *et al.*, 1982). Market prices were taken from the local market.

$$\textit{Maize equivalent yield} = Y_m + \frac{Y_i \times P_i}{P_m}$$

Where, Y_m is yield of maize (t/ha), Y_i is yield of cowpea (t/ha), P_i is price of cowpea (Rs/ha) and P_m is price of maize (Rs/ha)

Land equivalent ratio (LER)

Land equivalent ratio represents the area needed in sole cropping to match the yield of one hectare of intercropping or mixed cropping at the same spatial arrangement and expressed as ratio (Harwood, 1979). Willey (1979) given the formula as:

$$LER = \frac{Y_{ml}}{Y_m} + \frac{Y_{lm}}{Y_l}$$

Where, Y_{ml} is yield of maize when intercropped with cowpea, Y_m is the yield of sole maize, Y_{lm} is the yield of cowpea when intercropped with maize and Y_l is the yield of sole cowpea

Area time equivalent ratio (ATER)

The index was proposed by Hiebsch and Collum (1987) as a modification for LER. It incorporates the duration of the crop also.

$$ATER = \frac{L_m \times T_m \times L_c \times T_c}{T}$$

Where, L_m is partial LER of maize, L_c is partial LER of cowpea, T_p is duration of maize, T_c is duration of cowpea and T is duration of whole intercrop system

Benefit-cost ratio (BCR)

Economic profitability of cropping system was assessed by analyzing cost and benefits of system. The benefit-cost ratio (BCR) of treatments were calculated as follows:

$$BCR = \frac{Gross\ return\ (Rs/ha)}{Variable\ cost\ of\ cultivation\ (Rs/ha)}$$

The gross return was calculated using yield and local market price. The variable costs refers to expenses incurred during the field activity of production and varies according to the treatments.

Statistical analysis

The dataset was divided into hybrid and OPV's for better understanding of the relationship of yield and yield components in sole and intercrop. The one-way analysis of variance (ANOVA) was chosen to determine the effect of cropping system to yield and yield components. The treatments effects were separated by Duncan's Multiple Range Test (DMRT) test at 5% level of significance. The relationship between yield and yield components were fitted with linear equation. The disparities in grain yield and its attributes between cropping system, groups, and

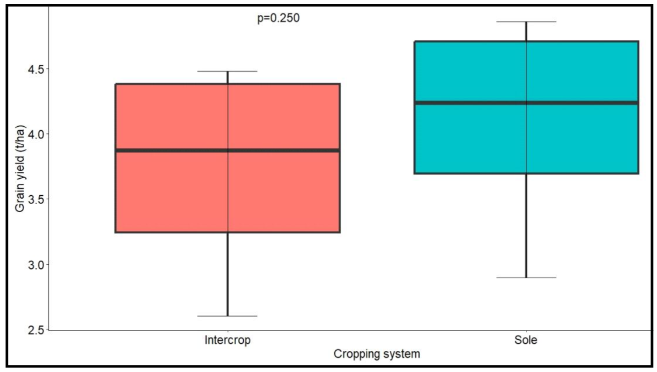

Fig. 4: Yield performance in sole and intercropping during winter, 2021/22.

within varieties were examined using the student's t-test. All statistical analysis and visualization were done using different packages of R (R core team, 2022).

Result

Maize grain yield

Non-significant difference of grain yield of maize was found in between sole and intercrop (Fig. 4). The grain yield of maize in intercrop was 3.73 t/ha, 8.63% lower than in sole (4.08 t/ha). However, the grain yield performance of different varieties of maize was diverse (Fig. 5). Intercropping significantly ($p<0.05$) reduced grain yield in Arun-2 and Rampur composite compared with the corresponding yield of sole. There was non-significant reduction in yield of Rampur hybrid-10 and Rasi-3033

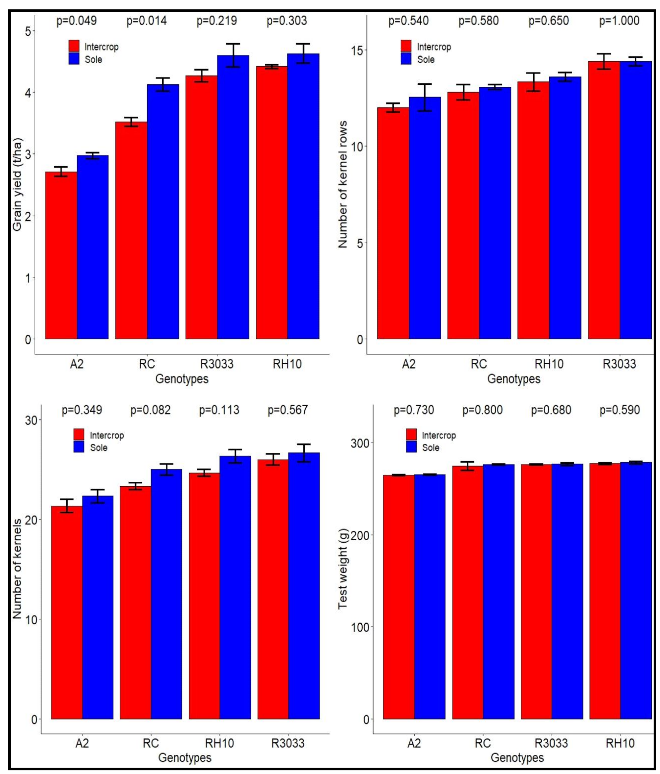

Fig. 5: Yield and itsattributes for varieties of maize in sole and intercropping in winter, 2021/22.

hybrid due to intercropping. Intercropping resulted in non-significant differences in the different yield attributes like number of kernel rows/cob, number of kernels/row and test weight. Non-significantly lower number of kernel rows/cob (13.13), number of kernels/row (23.83) and test weight (273.17g) were obtained in intercropping compared to the corresponding yield components of sole (Fig. 5).

Hybrids showed significantly higher grain yield, number of kernel rows/cob, number of kernel/row and test weight. In intercropping, open pollinated varieties cut down grain yield, number of kernel rows/cob, number of kernels/row and test weight by 28.23%, 10.58%, 11.84% and 2.53%, respectively than their reciprocal yield components of hybrids. The reduction of yield and its attributes of open pollinated varieties was lower in sole in comparison to the reduction of these components in intercropping, even though there was significant reduction of these components (compared to hybrids) in sole too (Fig. 6).

Association between yield and its components in sole and intercropping

Whether in sole or intercrop, grain yield of maize was strongly correlated with its components: number of kernel rows/cob, number of kernels/row and test weight. The relationship were linear in both cropping system for all components. The primary yield attributes for limiting yield in intercrop was number of kernels/row with higher coefficient of determination (R^2 = 0.72). However, test weight was the most important limiting factor in sole (R^2 = 0.91). The differences in yield between hybrid and OPV's in intercrop were associated with differences in number of kernel rows/cob and number of kernels/row. But, the differences in grain yield between two groups was related to differences in number of kernel rows/cob, number of kernels/row and test weight in sole (Fig. 7).

Intercrop performance of maize and cowpea varieties

The mean yield maize varieties was 4.08 t/ha (range: 2.97-4.63 t/ha), slightly higher than its corresponding intercrop yield (3.73 t/ha) (Table 2). The grain yield of different varieties were significantly differ in sole as well as in intercrop. The Rampur hybrid-10 and Rasi-3033 hybrid had similar productivities in intercrop and sole. The least yield was from Arun-2 under both system. The varieties were mainly varied in number of kernels rows/cob and number of kernels/row than test weight in both sole and intercrop. The highest number of kernels rows/cob and number of kernels/row were found in Rampur hybrid-10 and Rasi-3033 hybrid in sole and intercrop and among other varieties, only Arun-2 had much lower test weight compared with Rampur composite, Rampur hybrid-10 and Rasi-3033 hybrid. In case of cowpea, sole grown cowpea resulted significantly highest pod yield than intercropped.

The effect of cropping system on plant height is shown in Figure 8. There was significant difference between cropping system in the pooled plant height over genotypes. The hybrids did not show significant effect on plant height due to cropping system. But, the plant height of OPVs

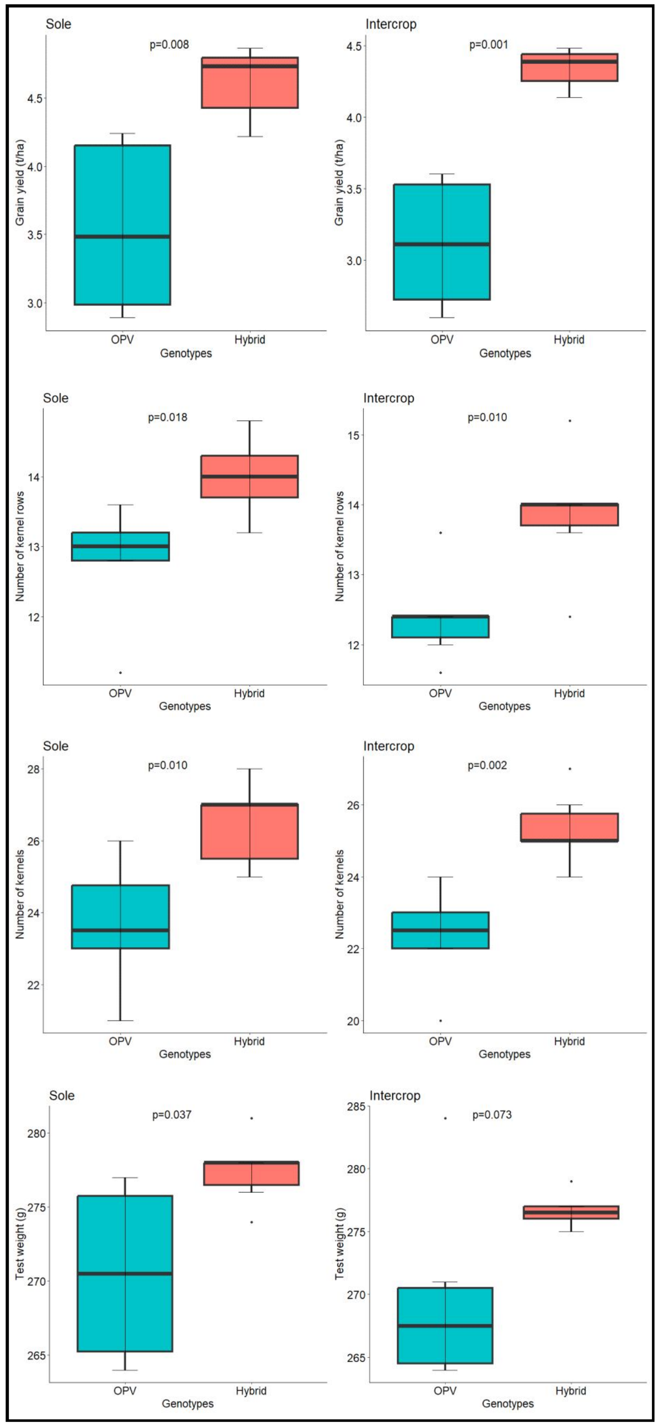

Fig. 6: Yield and itsattributes for different groups of maize in sole and intercropping during winter, 2021/22.

Table 2: The *per se* mean performance of maize and cowpea in sole and intercropping system in winter, 2021/22.

Cropping pattern	Varieties	Maize yield components				Cowpea pod yield (t/ha)
		Grain yield (t/ha)	NKPR	NRPC	Test weight (g)	
Sole	A2	2.97±0.05^{e}	22.33±0.67^{c}	12.53±0.71^{bc}	265.00±0.58^{b}	-
	RC	4.13±0.11^{c}	25.00±0.58^{ab}	13.06±0.13^{bc}	276.00±0.58^{a}	-
	RH10	4.63±0.15^{a}	26.33±0.67^{a}	13.60±0.23^{ab}	278.33±1.45^{a}	-
	R3033	4.60±0.19^{a}	26.67±0.88^{a}	14.40±0.23^{a}	276.67±1.33^{a}	-
	C	-	-	-	-	2.01±0.14^{a}
Intercrop	A2+C	2.71±0.07^{f}	21.33±0.67^{c}	12.00±0.23^{c}	264.67±0.67^{b}	0.51±0.05^{b}
	RC+C	3.52±0.08^{d}	23.33±0.33^{bc}	12.80±0.40^{bc}	274.67±4.70^{a}	0.56±0.06^{b}
	RH10+C	4.42±0.03^{ab}	24.67±0.33^{ab}	13.33±0.48^{ab}	277.33±0.88^{a}	0.53±0.05^{b}
	R3033+C	4.27±0.09^{bc}	26.00±0.58^{a}	14.40±0.40^{a}	276.00±0.58^{a}	0.60±0.06^{b}

A2 = Arun-2, RC = Rampur composite, RH10 = Rampur hybrid-10, R3033 = Rasi-3033 hybrid, C = Cowpea; NKPR = Number of kernels/row, NRPC = Number of rows/cob. Different letters with in column indicate significant ($p<0.05$) differences between cultivars. Values are mean±SE of three replicates.

were significantly ($p<0.05$) reduced in intercropping compared to sole cropping.

Productivity and economics of intercropping

The maize equivalent yield (MEY), land equivalent ratio (LER), area time equivalent ratio (ATER) and benefit-cost ratio (BCR) were found significantly differ among the cropping system (Table 3). Hybrid R3033+cowpea and RH10+cowpea resulted significantly higher MEY, LER and BC ratio. MEY of cowpea was statistically *at par* with RC intercropped with cowpea and sole RH 10 and R3033 hybrids, whereas BC ratio was statistically equivalent to both intercrop and sole RC and sole RH10 and R3033. LER of A2 intercropped with cowpea was statistically similar to the intercropped RH10 and R3033 hybrids. The ATER was significantly higher in intercrop A2, which was statistically *at par* with intercrop RH10 and R3033 hybrids. Least MEY and BC ratio was obtained in A2 as sole followed by intercrop A2.

Discussion

Although the plant density was same, maize produced low in intercrop compared with sole, with mean yield loss of 0.35 t/ha (Fig. 4) and magnitude of performance was affected by varieties (Fig. 5). This result line up noticeably with the results of others, e.g., maize/palisade grass or maize/guineagrass (Crusciol *et al*., 2020), wheat-maize/watermelon (Huang *et al*., 2019), maize/gardenpea (Khan *et al*., 2018). Earlier studies revealed that intercropping came up with a yield benefits at the individual plant levelof maize (Ofori and Stern, 1987; Mao *et al*., 2012; Kermah *et al*; 2017), owing to the beneficial effect of interspecific above-ground and/or below-ground interaction (Fukai and Trenbath, 1993; Li *et al*., 2016). Huang *et al*., (2017) showed that above-ground competition, not the nutrient availability, was the prime factor for yield restriction in wheat-maize/watermelon intercropping in china.

Table 3: Intercropping performance and economic profitability of maize-cowpea intercropping system in 2021/22.

Treatments	MEY (t/ha)	LER	ATER	BCR
A2	2.97^{e}	1.00^{c}	1.00^{c}	0.83^{c}
RC	4.13^{cd}	1.00^{c}	1.00^{c}	1.15^{b}
RH10	4.63^{bc}	1.00^{c}	1.00^{c}	1.29^{ab}
R3033	4.60^{bc}	1.00^{c}	1.00^{c}	1.28^{ab}
A2+C	3.84^{d}	1.17^{ab}	1.98^{a}	0.96^{c}
RC+C	4.75^{b}	1.13^{b}	1.79^{b}	1.20^{b}
RH10+C	5.57^{a}	1.23^{a}	1.90^{ab}	1.39^{a}
R3033+C	5.57^{a}	1.22^{a}	1.90^{ab}	1.39^{a}
C	4.39^{bc}	1.00^{c}	1.00^{c}	1.22^{b}
F-ratio	23.99	15.04	110.23	16.69
p-value	<0.001	<0.001	<0.001	<0.001
R^2	0.92	0.88	0.98	0.89

In our study, maize produced non-significantly higher grain yield in sole compared to intercrop with cowpea (Fig. 4). Higher yield of sole crop was also found by Feng *et al*., (2021) compared to intercrop in maize-soybean intercropping. In intercropping system, the yield of each crop species is generally below the yield of sole crop production, although the relative yield total is often higher than one (Yu *et al*., 2015; Martin-Guay *et al*., 2018) and the performance of crop greatly affected by the level of competition (Li *et al*., 2014). However, performance of OPV's was greatly varied between cropping system. The hybrid varieties didn't resulted in significant differences in grain yield performances (Figure 5) and plant height (Fig. 8) between sole and intercropping system. The hybrid performance remains stable environment to environment (Hyde, 1973). The OPV's has greater yield loss (11.76%) than hybrids (5.85%). This shrinkage in yield was connected with competition between multiple crops for resources, particularly the nitrogen as found by Crusciol *et al*., (2020).

Intercropping resulted in the more productive and higher economic returns of the crop land compared to sole crop (Table 3).LER>1 means intercropping benefits the growth and yield of the plants, while LER<1 means intercropping reduced the growth and yield of the plants in mixtures (Ofori & Stern, 1987). The present study result point out the greater efficiency of maize-cowpea intercropping in terms of land usage compared to monocultures. This result is also supported by the results of Alemayehu *et al*., (2018), Suarez *et al*., (2022), and El-Mehy *et al.,* (2023). The LER was significantly higher than unity indicates the benefits of intercropping compared to sole cropping in terms of the use of environmental resources for plant growth (Mead and Willey, 1980). ATER furnish more actual comparison of the yield benefits of intercropping over monocropping when land coverage time by intercrop components is different (Awal *et al*., 2007; Khonde *et al.,* 2018). ATER values exhibit

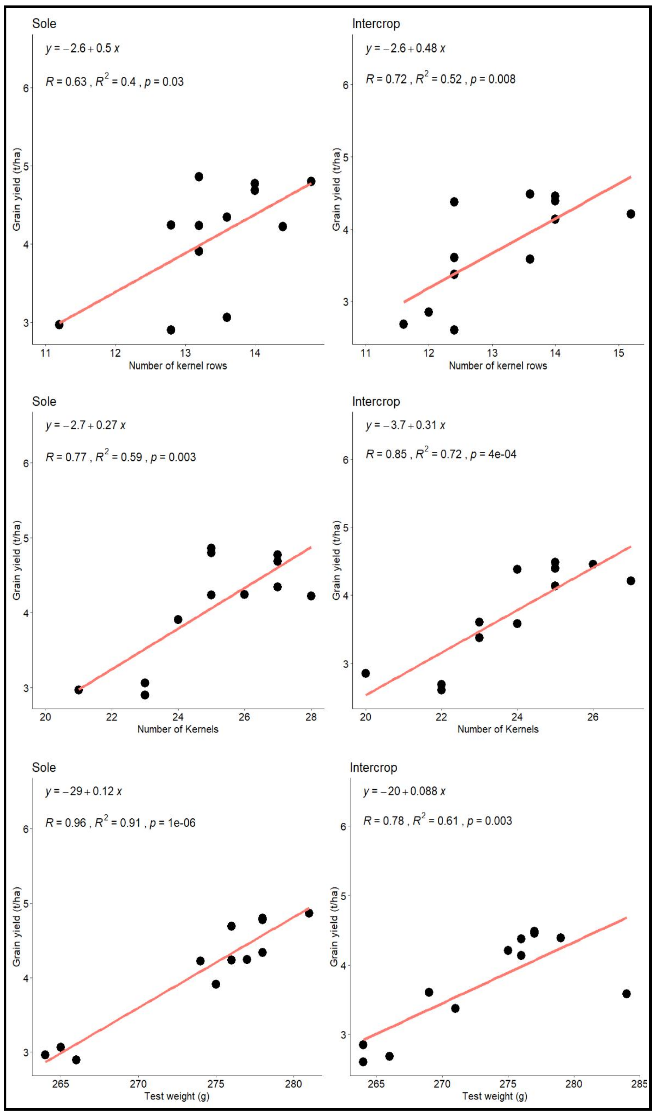

Fig. 7: Relationship between yield and its attributes for sole and intercropped maize in 2021/22.

an advantage of 98% at Arun-2 and cowpea intercropping and 90% in both hybrids with cowpea. This could be due to short crop duration of Arun-2 and higher crop productivity of hybrids. Hybrids in both intercropping and monocropping yielded more benefit than the other system. That is due to higher grain yield of hybrids than OPV. In this study, the ATER value was greater than LER pointed out the underestimation of resource utilization by LER. However, LERmade visible advantage ranged from 1 to 23%, while the value of ATER pointed out an advantages ranged from 1 to 98%. Adequate use of land resources in intercropping system than in sole cropping have also been reported by Uddin *et al*., (2014) and Doubi *et al*., (2016) for wheat intercropped with peanut and between cassava-bottle gourd intercropping, respectively. MEY and BC ratio were significantly higher in both hybrids intercropped with cowpea than others. Here, we got 5.57 t/ha MEY in both hybrids intercropped with cowpea which is higher than the base (maize) crop yield, thus the intercropping is advantageous. Akter Suhi *et al*., (2022) also found highest maize equivalent yield (MEY = 6.72 t/ha) from simultaneously sowing maize-cowpea intercropping. The BC ratio greater than 1 refers as beneficial intercropping system. However, crops and cropping practice with BC ratio higher than 1.5 is regarded as economically viable for farmers. The results were deviated than others researchers because the growth period of maize varieties was different and the cowpea was harvested at physiological maturity of pod.

In this study, the grain yield of hybrids (*viz*. Rampur hybrid-10 & R-3033) were higher than OPV's, which was attributed by number of grain rows/cob, grains/row and test weight (Fig. 6). Previous study of Raza *et al*., (2021) shows that the crop yield varied from variety to variety. The number of kernels/row, number of kernel rows/cob and thousand grain weight were the most important determinants for the grain yield as shown by a

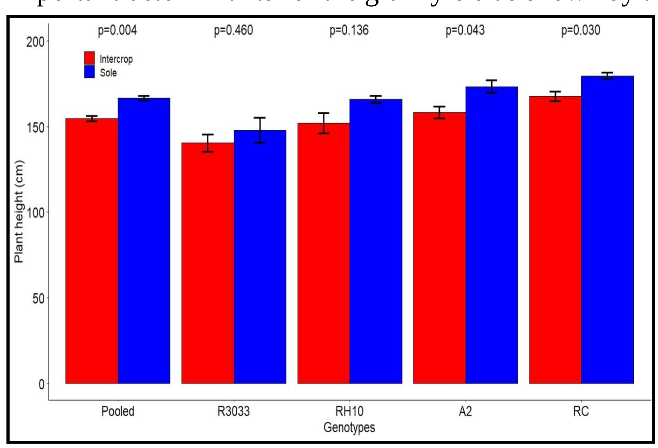

Fig. 8: Plant height of maize genotypes during flowering stage grown under sole and intercropping system in 2021/22.

significant and positive relationship of these variables with grain yield (Fig. 7). Huang *et al*., (2019) found ear density and 100-seed weight as major determinants for higher grain yield in intercrop. According to Andrade *et al*., (1999) the number of ear/plant and number of mature kernels/ear determined the number of kernels/plant, which is highly and positively associated with maize grain yield. The kernel number at harvest partly contribute to grain yield in maize (Tollenaar *et al*., 2000), which is highly affected by environment conditions (Lizaso *et al*., 2003). In this study, the kernel number setting and kernel filling stage were exposed to extremely low temperature in early stage (Fig. 2). With increment in number of kernel/ear and an elevated thousand grain weight under good agronomic practices contributes to an increase in yield/ plant (Qian *et al*., 2016). Intercepted photosynthetically active radiation (IPAR) close to silking (Kiniry and Knievel, 1995) is a most determinant variable for kernel set in maize. And, the LAI is one factor for determining radiation interception (Bonhomme, 2000). Higher radiation interception can result in greater productivity. Modern hybrids have improved capacity to maintain higher leaf photosynthetic rate of green leaf area during grain filling period (Tollenaar *et al*., 2000; Echarte *et al*., 2008) and the kernel number is the function of photosynthesis at the silking (Edmeades & Daynard, 1979). Thus, hybrids performed best in yield rather than inbred and OPV's, which was significantly observed in our present study too. However, the results are presented based on one year data only, so the results were differ than the other reported.

Conclusion

Different maize varieties has significant effects on the grain yield, number of kernel rows, number of kernels and test weight, among which Rampur hybrid-10 resulted in higher grain yield followed by Rasi-3033 variety, which was significantly attributed by higher number of kernel rows, number of kernels and test weight. The intercrop significantly lowered the grain yield of different maize varieties except Rampur hybrid-10. Since the maize-equivalent yield, land equivalent ratio and BC ratio were greatly higher in hybrid based intercropping, the hybrid based intercropping was more productive and economical than OPV based intercropping. Thus, the maize cultivars with high tolerability to inter-specific competition and stable yield components could improve the economic yield of maize-legume intercropping in farmer's field of mid-hills of Nepal. The inclusion of data on soil health, pest management and testing with different cowpea varieties could makes the findings of the research more applicable to farmer's level and policy levels.

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