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Partial Substitution of Hybrid Seeds with Open Pollinated Variety in Single Plant and Double Plants per Hill on Grain Yield and Yield Components of Maize (*Zea mays* L.)

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ABSTRACT

A field experiments was conducted at the Central Experiment Station of the University of the Philippines at Los Baños to evaluate mixed variety cultivation as productivity-enhancing and cost-saving strategies for maize production. The experiment was laid out in randomized complete block design with factorial arrangement of treatments in three replications. The variety DK 909, a hybrid was substituted with USM var 5, an open pollinated variety (OPV) of maize.

Mixed variety cultivation involved mixed stands of hybrid and open pollinated variety planted in single plant and double plants per hill. Two maize varieties currently grown in commercial scale in the Philippines were used in the study. Seed substitution significantly influenced grain yield. Nevertheless, there was no effect of interaction between seed substitution x number of plants per hill. Likewise, the differences in 100-grain weight, grain weight per plant, ear diameter, ear length, percentage of ear fill, and shelling recovery were not significant. Grain yield from the mixed stands of 75:25 and 50:50 in between hybrid and OPV were comparable with that of the pure stand of the hybrid. Substituting 75% of the recommended seed rate of the hybrid with OPV, however, resulted in significantly lower grain yield by 1,565 kg/ha. However, plant and ear heights were significantly affected by the interaction between seed substitution level x number of plants/hill. Simple regression analysis showed that grain weight per plant and percentage of ear fill accounted for 39% and 30% of the variations in grain yield, respectively. Therefore the study suggested that hybrid seed substitution could be done by OPV up to 50% levels in the subsistence agriculture. Economic analysis for cost and benefit showed that gross return was slightly higher in the pure stand of hybrid than that of 75:25 mixed stands of hybrid and OPV. The pure stand of the OPV gave the lowest gross return, cost of seeds, and return above variable cost.

Key words: partial substitution, grain yield, yield components, gross return, return above variable cost

INTRODUCTION

Maize, also called corn, is a merit crop which is used as food, livestock feed and industrial raw material which makes it one of the most important crops in the world (Koirala, 2002; Paudel, 2002). American Indians in Mexico first used it for food about 10,000 years ago. In terms of world grain production, maize is second after wheat while rice is third. In the year 2000, world maize production was about 615 million tons, 11.5% of which (71 million tons) was traded

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(Pingali, 2001). The USA leading producer of maize, produces in its corn belt about two-fifth of the world supply. The largest maize importing country is Japan, which imported 22.7% (16.1 million tons) of total maize traded in the world in the year 2000-01 while the largest exporting country (the USA) exported 70% (50 million tons) of the total maize traded in the same year (Koirala, 2002). Maize oil is likewise gaining popularity in the developed and developing world (Paudel, 2002). In the developing countries, farmers prefer maize to rice and wheat because of its adaptability to diverse agro-ecological conditions.

Maize is the world's most widely grown cereal and is the primary staple food in many developing countries. Almost half of the agricultural area in developing countries is planted to local varieties or landraces of maize (Morris *et al.,* 1999). In developing countries especially South and Southeast Asia maize growers are mostly subsistence farmers who do not have sufficient resources to adopt improved maize technologies which need high inputs such as improved seeds, chemical fertilizers, assured irrigation, plant protection, and marketing facilities.

In the South and Southeast Asian countries, maize is largely grown under rainfed condition. This explains a very low (less than 2.0 tons/ha) average yield of maize in these countries. The causes of low maize productivity are technical, biophysical, socioeconomic, and policy related in this part of the world. The technical constraints such as agronomic, variety and seed supply deserve immediate attention in any attempt to improve maize productivity. Intervention boosting maize productivity should address the poor economic status of the farmers. Multi-line culture or growing more than one variety in a farm in a crop cycle seems to offer an opportunity for alleviating expenses. Variety mixing can be done in two ways: seed mixing in different weight proportions, and planting at specific row proportions. Seed mixing may include open pollinated varieties (OPV) and hybrids or both are hybrids but of different height or canopy structure. Seed mixing can create roughness in the canopy surfaces of the plants because of height difference among OPV and hybrids. This roughness of canopy can increase carbon dioxide mixing more effectively than a uniform canopy such as growing of hybrid only. The practice of seed mixing could help exploit the genetic potential of maize varieties and could also be enhanced by agronomic manipulations. To date the impact of hybrid seed substitution with OPV on maize productivity is not known. In developed countries, mixing of OPV and hybrid maize is unpopular. Certain marketing standards in those countries render varietal mixing not technically feasible. While in developing countries, OPV and hybrid maize could be mixed provided grains are of the same color. Grains are largely used for feed ingredients and are not required to pass certain marketing standards such as uniform grain size and other quality parameters. Low maize productivity and income under subsistence farming condition are two issues that should be addressed. Low income might be addressed by reducing production cost. To reduce production cost a number of agronomic practices can be adopted. Exploiting the superior yield potential of hybrid may increase productivity. Hybrid maize cultivation in subsistence farming, however, is not common because planting F_1 hybrid seeds every growing season appears to be unaffordable for subsistence farming. Partial substitution of F_1 hybrid seeds with OPV is a possible option but the optimum combination level should be determined. Conversely, crop yield attained from the cultivation of OPV might be increased with partial substitution with F_1 hybrid seeds. Partial substitution of F_1 hybrid seed with OPV is perceived to be a cost-saving strategy. This strategy, however, is not supported by empirical evidence, hence this study.

MATERIALS AND METHODS

The experiments was conducted in 2004 at the Central Experimental Station, University of the Philippines at Los Baños (14^{0} 11 ‘N latitude, 121^{0} 15 ‘E longitude and 21 m above sea level), Laguna, the Philippines. The experiment was planted in February 19, 2004 and harvested in June, 2004. The varieties used were USM var 5 and DK 909. USM var 5 is a registered commercial open pollinated variety (OPV) developed by the University of Southern Mindano, the Philippines, and used in the National Co-operative Testing for corn as national check for new promising yellow open pollinated lines. It has a yield potential of 6.8 tons/ha, attains a height of 177-193 cm and matures in about 97 days (National Seed Industry Council, 1993). Variety DK 909 is a commercial hybrids developed by the Monsanto, the Philippines and has a yield potential of 7.6 tons/ha, matures in about 100 days, and attains the height of 183- 200 cm (National Seed Industry Council, 1994).

The experiment was laid out using the RCBD with factorial treatment arrangements replicated thrice separated by 1.50-m alleys. The first factor consisted of two levels of spacing (70 cm × 20 cm and 70 cm × 40 cm with single and double plants per hill, respectively). Both spacings had the same plant population of 71,428 plants/ha. The second factor was five levels of seed substitution based on seed count viz; 100% F_1 hybrid, 75% F_1 hybrid +25% OPV, 50% F_1 hybrid +50% OPV, 25% F_1 hybrid +75% OPV and 100% OPV. Thus, there were ten treatments for two levels of spacings and five levels of hybrid seed substitutions with OPV in the experiment. The treatments were randomly assigned to ten 22-m^2 plots in each block. Each plot had 6 rows 5.0-m long spaced 70 cm apart and 20 cm between plants for the single plant per hill and 40 cm for double plants per hill. Net harvested area per plot was 14 m^2 (4 rows of 5 m long).

The land was prepared by plowing once and harrowing twice. Furrows were opened 70 cm apart. Planting was done by hand at 20 cm spacing along the furrows with two seeds per hill in case of single plant and four seeds per hill in case of double plants per hill to assure desired stands. Twenty five days after planting, plants were maintained at single plant per hill and double plants per hill as demanded by the treatment combinations. Basal dose of 60 kg/ha each of N, P_20_5, and K_20 was sourced from a compound fertilizer (14:14:14) and was drilled uniformly in the furrows. A second dose of 60 kg N/ha was applied as top dress 30 days after planting (DAP) using urea (46% N). Manual weeding was carried out 25 DAP. Spot weeding was done two weeks after hilling up to preventing completely serious crop-weed competition. Hilling up was done at 30 DAP (just after applying the second dose of N). Plant protection was done by applying *Carbofuran* 3G (*2,3 dihydro 2, 2-dimethylbenzofuran methylcarbofuran*) which was applied in the whorl of leaves at 0.5 kg a.i./ha 30 DAP to control corn borer. The plots were irrigated 1 DAP using pressurized overhead irrigation system. Subsequent overhead irrigation was applied twice a week up to one month after planting so as not to expose the crop to severe drought stress. Thereafter, irrigation was applied through gravity system at weekly intervals when there was no sufficient rain. For grain yield determination, the inner two rows in each plot were harvested. The ears were counted and recorded as additional information. The moisture content of the grains was determined with a seed moisture tester just before weighing the seed bulk. Grain yield at 15% seed moisture content was computed from net harvested area of 14.0 m^2 per plot (4 rows of 5 m long). Individual ear attributes such as grain weight per ear, ear diameter, ear length, ear fill percentage, shelling recovery, and leaf area index (LAI) were recorded from all 25 plants in the central row of each plot. Grain yield, yield components and other plant parameters were recorded as the standard procedure described by the International Maize and Wheat Improvement Center (CIMMYT), Mexico. Recorded yield and plant attributes were analyzed using the general linear model (GLM) procedure of the Statistical Analysis Systems (SAS) software version 6.12. Mean comparison was done using LSD (least significant difference) method.

Soil samples were collected from the top 15 cm layer of the soil before planting and after harvesting. Soil sample analysis indicated that soil pH ranged from 6.13 to 6.33. Similarly, total N ranged from 0.08 to 0.11%, available P: 12.22 - 14.74 ppm, and exchangeable K: 0.52 - 0.71 meq/100 g. Bulk density was 1.12 - 1.2 g/cc while the percentages of sand, silt and clay were 9.3 - 12.7, 19.3 - 22.3 and 66 - 71%, respectively.

Meteorological parameters such as solar radiation, total evaporation, total rainfall, temperature, and relative humidity were recorded during the experimentation period from the Meteorological Station of International Rice Research Institute (IRRI) which is about 100 m away from the experimental site. Solar radiation was 18 MJ/m^2 at the time of planting and increased up to about 23 MJ/m^2 in the third decade of March and the second decade of April. Thereafter solar flux density decreased about 15 MJ/m^2 in the first decade of June. Rainfall during the second decade of February was quite low (5 mm) although it increased to around 18 mm in the third decade of February. March was totally rainless until the first decade of April. Trace quantity of rainfall was recorded in the second decade of April and rainless in the remaining decades of the same month. Rainfall started in May but the highest rainfall of around 80 mm was recorded in the first and second decades of June at which time the plants were at physiological maturity stage. Total evaporation was high (around 78 mm) in the third decade of April. Because of the high evaporation rate in March-April, irrigation was provided twice a week. The maximum temperature of about 32°C was recorded in April and May while the minimum of about 22°C was noted in February. Relative humidity in the dry season was lowest (79%) in the third decade of April and highest (88%) in the first decade of June.

The regression model used to establish relationship between grain yield and yield component was:

$$Y = \alpha + \beta X$$

Where, Y = dependent variable

α = intercept of the line on Y axis (i.e. the value of Y when the value of X is zero)

β = the linear regression coefficient, the slope of line or the amount of change in Y for each unit change in X

X = independent variable

RESULTS AND DISCUSSION

Grain yield and yield components

Seed substitution significantly influenced grain yield (Table 1) but neither the number of plants per hill nor the interaction between seed substitution x number of plants per hill affected grain yield and yield components (Table 1). Likewise, the differences in 100-grain weight, grain weight per plant, ear diameter, ear length, percentage of ear fill, and shelling recovery were not significant (Table 2). Substituting 75% of F_1 hybrid seeds with OPV (25% F_1 hybrid + 75% OPV) led to a significant reduction of grain yield by 1,399 kg/ha. The yield (3,225 kg/ha) obtained from this level of F_1 substitution was statistically similar to that of the yield (3,058 kg/ha) of the OPV in pure stand. As seed substitution for mixtures increased in favor of hybrid, increase of hybrid yield could not cover losses by competition between the two varieties. Closer examination of the different yield parameters on individual plant basis is deemed necessary. There was a balance compensation which showed that increasing the level of F_1 hybrid seeds substitution to 50% had no significant reduction of grain yield with pure stand of hybrid. Noteworthy is the increasing trend in grain yield as the level of F_1 seeds substitution was increased up to 75%. Considering the lower yield potential of OPVs compared to the hybrids, the increasing trend in grain yield as the proportion of F_1 hybrid in mixture decreased tends to indicate mutually beneficial plant-to-plant interaction in the

Table 1 Grain yield as affected by the number of plants per hill and level of hybrid seed substitution with OPV.

Hybrid seed substitution level [a]	Grain yield (kg/ha)		
	Single plant/ hill	Double plant/ hill	Mean grain yield
1	4812	4435	4624[a]
2	4748	4469	4608[a]
3	3960	3827	3894[ab]
4	3046	3403	3225[b]
5	2895	3223	3058[b]
CV %			18.8
F test [b]			
Hybrid seed substitution			**
No. of plants per hill			ns
Hybrid seed substitution x			
No. of plants per hill			ns
LSD			943

Grain yields with the same letter are not significantly different

[a] 1=100% F_1 hybrid (pure stand) 2=75% F_1 hybrid + 25% OPV
3=50% F_1 hybrid + 50% OPV 4=25% F_1 hybrid + 75% OPV
5=100% OPV (pure stand)

[b] * = P<0.05; ** = P<0.01 and ns = not significant

Table 2 Yield components of maize as affected by the partial substitution of F_1 hybrid with OPV.

Treatment[a]	Grain weight	100- Grain weight	Ear diameter	Ear length	Ear fill	Shelling recovery
	(g /plant)	(g)	(cm)	(cm)	(%)	(%)
1	68.6	20.4	4.0	14.0	84.0	79.0
2	68.5	20.2	4.0	14.0	86.0	80.0
3	69.9	21.2	4.0	15.1	82.0	78.0
4	72.0	21.7	4.0	14.1	83.0	79.0
5	61.1	21.5	4.1	13.0	82.0	77.0
CV%	21.3	9.0	4.2	13.2	5.2	5.0
F test [b]	ns	ns	ns	ns	ns	ns
LSD	11.8	2.4	0.7	2.4	5.5	5.1

[a] 1=100% F_1 hybrid (pure stand) 2=75% F_1 hybrid + 25% OPV
3=50% F_1 hybrid + 50% OPV 4=25% F_1 hybrid + 75% OPV
5=100% OPV (pure stand)

[b] * = P<0.05; ** = P<0.01 and ns = not significant

mixture leading to changes in certain yield components to compensate for the diminishing contribution of the hybrid to the composite yield of the mixed culture. These results clearly show the threshold level of seed substitution and likewise indicate the limit of each variety in balancing the gains and losses that might be normally encountered when two varieties differing in potential yield are mixed. Studies done by Hoekstra *et al.* (1985) and Midmore and Alkazar (1991) showed that varietal mixture in maize gave higher yield than their pure stands. There was an over compensation effect in mixed cultivar cultures, each cultivar tends to express their competitive ability which may result in high yields (Jensen (1952), Probst (1957), Jensen (1965), Brim and Schutz (1968), Schutz and Brim (1971), Hoekstra *et al.* (1985), Panse *et al*. (1989) and Zambezi *et al*. (1997) have likewise shown that yield obtained from mixed cultivar culture was higher than in pure stands. In this study, the mixed stands of hybrid and OPV up to 50:50 seed substitution gave yield about average between the two varieties (3841 kg/ha) which was comparable to pure stand of hybrid. This was the effect of balance compensation of seed substitution between hybrid and OPV. The finding suggests that hybrid seed substitution could be done by OPV up to 50% levels which is quite economical for poor farmers in the subsistence agriculture.

Other agronomic traits

Significant differences in plant and ear height (Table 3) were attributed to the interaction between level of seed substitution x number of plants per hill. Plants tended to become shorter when grown in pairs per hill in each mixed culture. The magnitude of change in plant height, however, varied among the treatments. The significant decline in plant height associated with the change in number of plants per hill from single to double was highest in the 50% F_1 hybrid + 50% OPV

Table 3 Plant and ear height responses with respect to the number of plants per hill and seed substitution.

Treatment[a]	Plant height (cm)		Ear height (cm)	
	Single plant/ hill	Double plants/ hill	Single plant/ hill	Double plants/ hill
1	174	167	89	99
2	201	196	99	111
3	209	159	105	91
4	173	164	95	99
5	190	178	101	102
CV%	3.8		5.2	
F test[b]				
Seed substitution	**		*	
Spacing	ns		ns	
Seed substitution x spacing	**			
**				
LSD	9		7	

[a] 1=100% F_1 hybrid (pure stand) 2=75% F_1 hybrid + 25% OPV
3=50% F_1 hybrid + 50% OPV 4=25% F_1 hybrid + 75% OPV
5=100% OPV (pure stand)

[b] * = P<0.05; ** = P<0.01 and ns = not significant

mixture followed by the OPV in pure stand. The lowest was noted in the 75% F_1 hybrid + 25% OPV mixture but the difference was not significant. Apparently, the degree of plant-to-plant competition was greater in pairs per hill than in single plant per hill. In plant populations where plant height was inherently non-uniform like USM var 5 (OPV) in pure stand, plant-to-plant competition could be very rigid leading to the growth suppression of the less vigorous plants. Similar degree of competition could have occurred in the 50% F_1 hybrid + 50% OPV mixed culture with some of the less vigorous hybrid plants having been suppressed by the taller and more vigorous plants of the OPV.

Based on the average height of the F_1 hybrid in pure stand, the changes in height of single plant per hill were greater than those in pairs per hill. The results likewise indicate that plants in the three different combinations of F_1 hybrid and OPV were significantly taller than those in the pure stand of F_1 hybrid except those in the 25% hybrid + 75% OPV mixtures which were slightly shorter. Similar trend was noted in plants maintained in pairs per hill but the difference was smaller. Contrary to the observation in single plant per hill in the 50% hybrid + 50% OPV combination in which average plant height was higher by about 20% than those in the pure stand of F_1 hybrid, plants in pairs per hill in the same combination were significantly shorter. These observations indicate the instability of height when individual plants were exposed to various level of plant-to-plant interaction at different magnitudes of substitution.

Plants maintained in pairs per hill had ears farther from ground (ear height) than the single plant per hill except those in the 50% F_1 hybrid + 50% OPV mixture which showed the opposite (Table 3). Variations among F_1 hybrid + OPV combinations in single plant per hill were significant except those in the 25% F_1 hybrid + 75% OPV mixture which had ears as high as those in the pure stand of F_1 hybrid. The plants maintained in pairs per hill showed the opposite trend whereby those in the 25% F_1 hybrid + 75% OPV had slightly lower ears than the F_1 hybrid in pure stand. The differences are clearly not understood at this point. Differential elongation of internodes which was probably affected by differences in plant vigor and thus the degree of plant-to-plant interaction in each mixture might partly explain the trend.

The differences in 50% tasseling, 50% silking, stalk diameter, and leaf area index (LAI) at 45, 55, and 65 DAP were not significant (Table 4) indicating the stability of these traits, and morphological similarities between the two varieties. Variation in 50% tasseling and silking was about one day. Stalk diameter ranged from 2.6 to 3.0 cm. LAI ranged from 2.7 to 3.8. Peak LAI was recorded at 65 DAP and slightly declined at 55 DAP in the pure stand of the F_1 hybrid, and in the 50% hybrid and 50% OPV, and 25% hybrid + 75% OPV mixtures. The number of functional leaves above the ear (NLAE), however, varied. Regardless of the number of plants maintained per hill, the F_1 hybrid in pure stand had significantly higher NLAE than the pure stand of OPV. Likewise, NLAE was also significantly lower in the 75% F_1 hybrid + 25% OPV and 25% F_1 hybrid + 75% OPV mixtures than in the pure stand of F_1 hybrid.

Relationship between grain yield and yield components

Simple linear regression analysis was carried out to establish a basis for determining the yield component(s) that may explain the differences among treatments in terms of grain yield. The results showed that grain weight per plant ($P<0.001$) and ear fill percentage ($P<0.001$) were significantly related to grain yield (Table 5). Grain weight per plant accounted for 39% of the variations in grain yield while ear fill percentage accounted for 30%.

Table 4 Effect of F_1 hybrid seed substitution with OPV on agronomic traits.

Treatment [a]	Days to 50% tasseling	Days to 50% silking	Stalk diameter (cm)	NLAE [C] (No.)	Leaf area index		
					45 DAP	55 DAP	65 DAP
1	48.3	53.5	2.9	11.2	2.9	2.9	3.2
2	49.0	54.5	2.6	10.5	3.0	3.0	3.5
3	49.0	54.3	2.9	11.1	3.1	3.0	3.6
4	48.7	54.0	3.0	10.9	2.7	2.7	3.4
5	49.0	54.0	3.0	10.8	3.0	3.0	3.6
CV%	2.7	2.7	6.7	3.2	8.6	8.7	8.9
F test [b]	ns	ns	ns	*	ns	ns	ns
LSD	1.7	1.8	0.4	0.5	0.4	0.3	0.3

[a] 1=100% F_1 hybrid (pure stand) 2=75% F_1 hybrid + 25% OPV
3=50% F_1 hybrid + 50% OPV 4=25% F_1 hybrid + 75% OPV
5=100% OPV (pure stand)

[b] * = P<0.05; ** = P<0.01 and ns = not significant

[c] NLAE= No. of leaves above ear at 55 DAP

Table 5 Relationship between bulk grain yield and yield components as influenced by seed substitution and number of plants per hill (n=30).

Variable	Intercept	Coefficient	P-value	R^2
100- grain weight	1850.4	97.0	0.368	0.029
Grain weight per plant	1125.5	40.5	0.000	0.392
Ear diameter	2202.3	416.8	0.840	0.001
Ear length	1390.3	177.1	0.085	0.102
Ear fill	505.0	292.8	0.001	0.307
Shelling recovery	2226.7	21.1	0.542	0.013

Economics of F_1 hybrid seed substitution

A simple economic analysis of hybrid seed substitution with OPV was done in the study. Villegas *et al.* (2004) established that total variable cost of maize seed was 4.87 Philippines Peso per kilogram of seed. On this basis, total variable cost is calculated in the study. An economic analysis showed that gross return was lowest in the pure stand of OPV (Table 6). The results also indicate that the gross return obtained from the pure stand of the hybrid was highest among the treatments. Gross return decreased when the level of hybrid seed substitution was increased which obviously indicates that the OPV was ineffective to compensate for the diminishing contribution of the hybrid to gross income. It has indicated that the OPV has inferior yield potential compared to the hybrid. One advantage of the OPV over the hybrid, however, was the twelve-fold difference in cost of the seeds, which could even be higher under actual production conditions considering farmers' practice of saving some seeds from their harvest for the next season planting. Thus, the cost of seeds could be virtually zero. Despite the obvious seed cost advantage of the OPV, the return above variable cost (RAVC) was higher in the pure stand of the hybrid and in mixed stands where hybrid seed substitution level was 25-50%. Since the compensation of yield in mixtures is in the range of under compensation to balance compensation.

Table 6 Return above variable cost as influenced by the magnitude of F_1 hybrid seed substitution with OPV.

Treatment [a]	Grain yield (kg /ha)	Gross return (GR)[b] (Ph P)	Seed cost (SC)[c] (Ph P)	Return above variable cost (RAVC)[d] (Ph P)
1	4624	36992	2400	14473
2	4608	36864	1850	14973
3	3894	31152	1300	13288
4	3225	25800	750	11744
5	3058	24472	200	11775

[a] 1=100% F_1 hybrid (pure stand) 2=75% F_1 hybrid + 25% OPV
3=50% F_1 hybrid + 50% OPV 4=25% F_1 hybrid + 75% OPV
5=100% OPV (pure stand)
[b] Farm gate price of maize=Philippines Peso (Ph P) 8.0 per kg, August 2004
[c] SC for F_1 hybrid per hectare= Ph P 2400.0, SC for OPV per hectare = Ph P 200.0, August 2004
[d] RAVC=GR-TVC that vary due to seed cost
Buying rate of 1 US$ = 56 Philippines Peso (Ph P)

There is no advantage of any mixtures ratio. Growing hybrid in pure stands should have an advantage on crop management and economically highest return.

CONCLUSION

Grain yield from the mixed stands of 75:25 and 50:50 seed substitution between hybrid and OPV was not significantly lower than the yield of pure stand of hybrid. Substituting 75% of the recommended seed rate of the hybrid with OPV, however, resulted in significantly lower grain yield. Conversely, grain yield was significantly higher in mixed stands of 75:25 and 50:50 than the yield of pure stand of OPV. Difference in the agronomic traits such as number of leaves above ear, plant and ear height were recorded significant while days to 50% silking and tasseling, stalk diameter, and leaf area index were not significant. Simple cost and benefit analysis showed that gross return was slightly higher in the pure stand of hybrid than that of 75:25 mixed stand of hybrid and OPV while the pure stand of OPV gave the lowest gross return.

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