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Response of mass selection in maize (*Zea mays* L.)

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Abstract

This study was conducted to quantify the progress towards grain yield and agronomic traits in maize genotypes through mass selection. The original maize population and the population derived after five cycles of mass selection were planted for comparison at research field of National Maize Research Program, Rampur, Chitwan, Nepal during winter season of 2011-2012. The maize genotypes were Arun-1EV, Arun-4, Pool-17, P501SRCO × P502SRCO, BGBYPOP, Across9942 × Across9944, S99TLYQ-B, S99TLYQ-AB and S01SIWQ-3, respectively. The experiment was laid down in randomized complete block design with three replications. Each replication consisted of 180 rows; 20 rows of each genotypes. The results showed that there was significant reduction in plant height, ear height, tasseling days, silking days, disease severity however significant increment in grain yield. The results showed that phenotypic superiority of the selected population over the original population was obvious.

Key words: Maize genotypes, Ass selection, Agronomical traits, Grain yield.

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Introduction

The mass selection is a breeding method in which individual plants are selected on the basis of phenotypes and a balanced seed bulk from the selected plants is composited to propagate next selection cycle. Prior to the selection of individuals, crop is grown in the field which is first divided into smaller selection units (field stratification), minimizing the bias due to field heterogeneity. The differences among plants within field's sections are more likely to be due to genetic differences than to environmental effects (Hallauer *et al.,* 2010). Mass selection has been successfully used by maize growers to increase productivity (Gardner, 1977; Zorilla and Crane, 1982) and yield components (Salazar and Hallauer, 1986; Odhiambo and Compton, 1987). Maize breeders have suggested the possibility of producing superior open pollinated varieties (OPV) from advanced cycles of selected populations in developing countries (Eberhart *et al.*, 1967; Darrah *et al.*, 1978).

The phenotypic performance based on the selection of individual plants is the simplest way to improve crops. Lonnquist (1967) who applied five generations of mass selection to increase productivity in maize using correlated characters for prolificacy found that the gain in yield per cycle of 6.25% approximated that obtained when direct selection was used for weight of grain per plant. After 10 cycles of mass selection for prolificacy in maize composite BC10, grain yield was increased by 2.6% per cycle (Subandi, 1990). The grain yield was increased significantly with the application of all the selection criteria used, which included ear length, prolificacy, anthesis-silking interval and harvest index (Biasutti *et al.,* 2000). Specifically, for the length of the ear, an increase of 2.8% was reported after four selection cycles were performed. The 10 cycles of mass selection for yield in the maize cultivar (Zacatecas 58) resulted in an average genetic advance of 3.25% per cycle (Vargas *et al.,* 1982). Although mass selection has been used primarily to improve performance, its usefulness in improving other plant characters has also been documented. A gain of 3.3% per cycle in the emergence of seedlings using mass selection (Bell *et al.*, 1983). Similarly, Cortez-Mendoza and Hallauer (1979) who exercised mass selection in ear length for IOWA Long Ear Synthetics and observed that 10 cycles of mass selection produced a highly significant average increase of 0.32 cm per generation. In Nepal stratified mass selection are generally used for maintenance and improvement of promising prerelease and released maize varieties.

The objectives of this study were to quantify the progress in grain yield and other agronomic traits in maize genotypes namely Arun-1EV, Arun-4, Pool-17, P501SRCO × P502SRCO, BGBYPOP, Across9942 × Across9944, S99TLYQ-B, S99TLYQ-AB and S01SIWQ-3 at Rampur, Chitwan condition of Nepal.

Materials and methods

Experimental site and genetic materials

This experiment was conducted at research field of National Maize Research Program (NMRP), Rampur, Chitwan (27°37' N and 84°25'E, alt. 256 m asl), Central Nepal during winter season (from September 2011 to February 2012).

Multiple agronomic traits selection in 9 maize genotypes were derived from original and selected populations namely Arun-1EV, Arun-4, Pool-17, P501SRCO × P502SRCO, BGBYPOP, Across9942 × Across 9944, S99TLYQ-B, S99TLYQ-AB and S01SIWQ-3 The selected maize population (derived after five cycles of mass selection) was received from Plant Breeding section of NMRP office.

Experimental design, details and cultural practices

The experiment was laid down in randomized complete block design with three replications. Each replication consisted of 180 rows; 20 rows of each genotype (i.e. 10 rows for genotype from original population and 10 rows for genotype from selected population). Row length was 5 m, which were row spaced at 75 cm and the plant to plant spacing was 25 cm resulting in a population of about 53,333 plants/ha. The main objective of the study was to observe the effects of multiple traits selection after five cycles of mass selection in comparison to original (unselected) population. Selection was made on the basis of phenotypic superiority. A random sample of hundred plants was taken from each plot for comparison of grain yield and other agronomic traits.

Irrigations were provided on basis of as required during the entire crop season. A basal dose of fertilizer of 120 kg nitrogen, 60 kg of phosphorus and 40 kg of potash was applied in the form of urea, DAP and MoP. Full dose of phosphorus and potash along with half dose of nitrogen was applied at the time of seed sowing. The remaining half dose of nitrogen fertilizer was side dressed when plants were 10-15 cm tall. Diazinon 10 G was used in shoots after 25 days of sowing followed by spot application thereafter, whenever required for the control of maize stem borer. Standard cultural practices were applied from sowing till harvest.

Data collection and analysis

Data were recorded on the agronomic parameters using either standing crop or the harvested material. Plant height, ear height, plant aspect, ear aspect and disease score were recorded.

Disease severity scale and reaction type was recorded as below;

1 = Resistant, Plants with one or two to few scattered lesions on lower leaves

2 = moderately resistant, Moderate number of lesions on leaves, affecting less than 25 percent of the area

3 = moderately susceptible, Abundant lesions on lower leaves, few on other leaves affecting 26- 50% leaf area

4 = Susceptible, Lesions abundant on lower and mid leaves, extending to upper leaves affecting 51- 75 % leaf area

5 = Lesions abundant on almost all leaves, plant prematurely dried or killed with 76 - 100% of the leaf area affected.

Plant aspect scoring was done from 1-5 scale where 1= short plant with uniform and short ear placement, 5= tall plant with higher ear placement.

The ear aspect was scored from 1-5, where 1= nice and uniform cobs with desirable texture in the area, 5= ugly cobs with undesirable texture in the area.

Grain yield (kg/ha) at 15% moisture content was calculated using fresh ear weight following Carangal *et al.* (1971) and Shrestha *et al.* (2018) as follows:

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

Where,
F.W. = Fresh weight of ear in kg/plot at harvest
HMP = Grain moisture percentage at harvest
DMP = Desired moisture percentage, i.e. 15%
NPA = Net harvest plot area, m^2
S = Shelling coefficient, i.e. 0.8

Statistical analysis

Statistical analysis was carried out for the above-mentioned traits using computer software MSTATC version 6.4.1. Least significant difference test was used at 0.05 probability level for the separation among the population means (Gomez and Gomez, 1984).

Results

Tasseling days

The days to 50% tasseling was highly significant for genotypes. The difference in days to 50% tasseling was observed 12 to 14 days earlier in selected population of OPV full season than original population. The days to tasseling were observed 6 days earlier to 9.5 days later than original population of quality protein maize (QPM) varieties whereas, 6 days earlier to 4 days later days to tasseling than original population of OPV early. In this study the difference in days to tasseling was higher in OPV full season than the QPM and OPV early because of more selection pressure was given to OPV full season varieties than other varieties (Table 1).

Silking days

The days to 50% silking were highly significant for genotypes. The difference in days to 50 % silking was observed 11 to 16 days earlier in selected population of OPV full season than original population. The days to silking were observed 4 days earlier to 9 days later than original population of QPM varieties whereas, 2 days earlier to 3 days later days to silking than original population of OPV early. In this study the difference in days to silking was higher in OPV full season than the QPM and OPV early because of more selection pressure was given to OPV full season varieties than other varieties (Table 1).

Plant height

The difference in plant height was observed 26 to 40 cm shorter in selected population of OPV full season than original population. The plant height was observed 10 to 53 cm shorter than original population of QPM varieties whereas, 5 to 10 cm shorter than original population of OPV early. In this study the difference in plant height reduction was higher in QPM than the OPV full season and OPV early because of more selection pressure was given to QPM varieties than other varieties (Table 2).

Ear height

The ear height was highly significant for genotypes. The difference in ear height was observed 6 to 17 cm shorter in selected population of OPV full season than original population. The ear height was observed 10 to 18 cm shorter than original population of QPM varieties whereas, 1 to 5 cm shorter than original population of OPV early. In this study the difference in ear height reduction was higher in OPV full season than the QPM full season and OPV early because of more selection pressure was given to OPV full season than other varieties (Table 2).

Plant and ear aspect

The plant aspect and ear aspect were non-significant for genotypes. The the difference in plant aspect was observed 0.7 to 1 lower in selected population of OPV full season than original population. The plant aspect was observed 0.8 to 1.8 lower than original population of QPM varieties whereas, 0.9 to 1.8 lower than original population of OPV early. In this study the difference in plant aspect reduction was higher in QPM than the OPV full season and OPV early because of more selection pressure was given to QPM varieties than other varieties (Table 3).

The difference in ear aspect was observed 0.1 to 0.5 lower in selected population of OPV full season than original population. The ear aspect was observed 0 to 1.4 lower than original population of QPM varieties whereas, 0.5 to 1.7

Table 1. Comparative study of maize genotypes derived from original and selected population for flowering days at Rampur, Chitwan, 2011-12 winter season

Genotypes	50 % Tasseling days			50 % Silking days		
	Original population	**Selected population**	**Difference**	**Original population**	**Selected population**	**Difference**
OPV Full season						
Across9942 × Across9944	74	62	-12	77	66	-11
P501SRCO × P502SRCO	88	75	-13	93	78	-15
BGBYPOP	91	77	-14	95	79	-16
QPM Full season						
S99TLYQ-B	75	75	0	80	80	0
S99TLYQ-AB	59	68.5	+9.5	64	73	+9
SO1SIWQ-3	76	70	-6	79	75	-4
OPV Early						
Pool-17	59	53	-6	60	58	-2
Arun-1EV	54	53	-1	56	57	-1
Arun-4	58	62	+4	62	65	+3
CV%	1.7	2.4		1.4	2.9	
LSD (0.05)	2.82	3.68		2.3	4.61	
F-test	**	**		**	**	

*** Significant at 0.01 level of significance*

Table 2. Comparative study of maize genotypes derived from original and selected population for plant height and ear height at Rampur, Chitwan, 2011-12 winter season

Genotypes	Plant height (cm)			Ear height (cm)		
	Original population	**Selected population**	**Difference**	**Original population**	**Selected population**	**Difference**
OPV Full season						
Across9942 × Across9944	240	214	-26	112	100	-12
P501SRCO × P502SRCO	223	194	-29	117	100	-17
BGBYPOP	220	80	-40	114	108	-6
QPM Full season						
S99TLYQ-B	212	202	-10	112	102	10
S99TLYQ-AB	216	163	-53	99	81	-18
SO1SIWQ-3	211	158	-53	110	95	-15
OPV Early						
Pool-17	210	205	-5	82	81	-1
Arun-1EV	221	211	-10	108	106	-2
Arun-4	185	180	-5	78	73	-5
CV%	2.5	4.1		4.9	25.7	
LSD (0.05)	11.58	18.46		11.41	51.33	
F-test	**	**		**	ns	

*ns: Non significance, ** Significant at 0.01 level of significance*

Table 3. Comparative study of maize genotypes derived from original and selected population for plant aspect and ear aspect at Rampur, Chitwan, 2011-12 winter season

Genotypes	Plant aspect (1-5)			Ear aspect (1-5)		
	Original population	**Selected population**	**Difference**	**Original population**	**Selected population**	**Difference**
<u>OPV Full season</u>						
Across9942 × Across9944	2.6	1.9	-0.7	2	2	0
P501SRCO × P502SRCO	2.9	2.1	-0.8	2.7	2.2	-0.5
BGBYPOP	2.3	1.3	-1.0	2	2.1	+0.1
<u>QPM Full season</u>						
S99TLYQ-B	2.6	1.5	-1.1	2.8	1.4	-1.4
S99TLYQ-AB	2.8	1	-1.8	1.9	1	-0.9
SO1SIWQ-3	2.5	1.7	-0.8	2.3	1.8	-0.5
<u>OPV early</u>						
Pool-17	3	2.1	-0.9	3	1.6	-1.4
Arun-1EV	3	1.2	-1.8	2.5	2	-0.5
Arun-4	2.5	1.1	-1.4	3	1.3	-1.7
CV%	10.7	21		14.5	8	
LSD (0.05)	0.66	0.778		0.82	0.316	
F-test	ns	ns		ns	**	

*ns: Non significance, ** Significant at 0.01 level of significance*

lower than original population of OPV early. In this study the difference in ear aspect reduction was higher in QPM than the OPV full season and OPV early because of more selection pressure was given to QPM varieties than other varieties (Table 3).

Disease score

The disease (BLSB and ear rot) score in maize genotypes was significant. The disease score was reduced in selected population as compared to original population (Table 4).

There was not improvement in disease severity in case of Maydis between the original and selected population of tested genotypes. However, disease severity has been reduced in case of BLSB on BGBYPOP, S99TLYQ-AB and Pool 17. Similarly, disease severity in case of ear rot has been significantly reduced on Across9942 × Across9944, S99TLYQ-B, S99TLYQ-AB, SO1SIWQ-3 and Pool-17. The maize disease severity was increased in P501SRCO×P502SRCO in selected population as compared to its original population which leads to grain yield reduction in selected population of this genotype.

Grain yield

The grain yield difference was observed by 909 kg/ha reduction in P501SRCO × P502SRCO but the grain difference increased by 639 kg/ha in Across9942 × Across9944 and 1051 kg/ha in BGBYPOP in selected population of OPV full season than their original population. The grain yield difference was observed 295 to 1194 kg/ha higher than original population of QPM varieties whereas, 75 to 392 kg/ha higher than original population in case of OPV early. In this study the difference in grain yield increment was higher in QPM than the OPV full season and OPV early because of more selection pressure was given to QPM varieties than other varieties.

The grain yield was significant for genotypes (Table 5). The genotypes of selected population produced higher grain yield than that of the original population except the genotype namely P501SRCO × P502SRCO. This showed that genetic progress was made through five cycles of selection resulting in significant improvement in yield. This significant increase in grain yield of the selected population may be attributed toward improvement in other physiological and yield related traits.

Table 4. Comparative study of maize genotypes derived from original and selected population for disease severity at Rampur, Chitwan, 2011-12 winter season

Genotypes	Maydis (1-5)		BLSB (1-5)		Ear rot (1-5)	
	Original population	**Selected population**	**Original population**	**Selected population**	**Original population**	**Selected population**
OPV Full season						
Across9942 × Across9944	2	2	2.3	2	3	1
P501SRCO × P502SRCO	2	2.8	2	2.4	1	1.1
BGBYPOP	1.5	1.5	2.6	2	1.4	1
QPM Full season						
S99TLYQ-B	3	3	2.5	2.5	1.6	1.2
S99TLYQ-AB	2	2	2.9	2	1.7	1
SO1SIWQ-3	2	2	2.4	2	2.6	2
OPV Early						
Pool-17	2.6	2.8	3.6	3	3.7	3
Arun-1EV	2.3	2.5	4.3	4	3.3	3.3
Arun-4	2.3	2.3	3.3	3	2.3	2.3
CV%	20.1	9.2	6.7	8.8	12.2	15.2
LSD (0.05)	1.05	0.492	0.45	0.508	0.652	0.619
F-test	ns	**	**	**	**	**

*ns: Non significance, ** Significant at 0.01 level of significance*

Table 5. Comparative study of maize genotypes derived from original and selected population for grain yield at Rampur, Chitwan, 2011-12 winter season

Genotypes	Grain yield (kg/ha)		
	Original population	**Selected population**	**Difference**
OPV Full season			
Across9942 × Across9944	4305	4944	+639
P501SRCO × P502SRCO	5210	4301	-909
BGBYPOP	4504	5555	+1051
QPM Full season			
S99TLYQ-B	5456	6014	+558
S99TLYQ-AB	5013	5308	+295
SO1SIWQ-3	4204	5398	+1194
OPV Early			
Pool-17	3710	3800	+90
Arun-1EV	4405	4480	+75
Arun-4	4209	4601	+392
CV%	5.7	29.8	
LSD (0.05)	604	1116.5	
F-test	*	*	

** Significant at 0.05 level of significance*

Discussion

The effects of mass selection on grain yield and other agronomic traits were studied. The comparative study between original maize population and the population derived after five cycles of mass selection was carried out. The grain yield was found higher in maize population derived from five cycle's mass selection. The present study was similar to findings of Jasa-Vega (1985) who observed the increase in grain yield in maize by mass selection. The results are in accordance with the results reported by Gardner (1961, 1969), Johnson (1963), Lonnquist (1967), Arboleda-Rivera and Compton (1974), Taran *et al.* (2004) and Rahman *et al.* (2007) who noted substantial grain yield gains in maize populations following mass selection. Mass selection significantly increased grain yield 12 to 15% on the average in maize (Mareck and Gardner, 1979). The reduction in plant height in mass selected population was highly significant for genotypes. This finding was similar to Khan *et al.* (1983) who found that the maize population developed by mass selection was lower in plant height than their original population. Miles *et al.* (1980) noticed that the mass selection was the most efficient method of improving disease resistance in maize populations. This results presented here concur with the results previously described for the Portuguese Pigarro maize population (Vaz Patto *et al.*, 2008) where stratified mass selection demonstrated to be an effective way to conserve diversity on-farm, and at the same time allowed relevant phenotypic improvements to be achieved.

Conclusion

The phenotypic superiority of maize genotypes in population derived from five cycles of mass selection over the original population was obvious. The maize genotypes derived after five cycles of selection manifested the higher grain yield, lesser plant height and ear height, better plant and ear aspect, lesser disease and insect infestation as well as earlier in silking and tasseling days as compared with that parameters of the original population. Thus, the five cycles of mass selection were found effective for improvement of agronomic traits in maize populations.

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References

Arboleda-Rivera, F. and W.A. Compton 1974. Differential response of maize (*Zea mays* L.) to mass selection in diverse selection environments. *Theor. Appl. Genet* ***44***: 77-81.

Bell, R.D., L.L. Darrah and M.S. Zuber 1983. Progress from mass selection for field emergence and seed weight in a sh2 population of maize. *Crop Sci* ***23***: 461-464.

Biasutti, C.A., F. Casanoves and D.A. Peiretti 2000. Response to different adaptive mass selection criteria in a maize exotic population. *Maydica* ***45***: 89-94.

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

Cortez-Mendoza, H. and A.R. Hallauer 1979. Divergent mass selection for ear length in maize. *Crop Sci* ***19***: 175-178.

Darrah, L.L., S.A. Eberhart and L.H. Penny 1978. Six years of maize selection in Kitale synthetic II. *Euphytica* ***27***: 191-204.

Eberhart, S.A., M.N. Harrison and F. Ogada 1967. A comprehensive breeding system. *Zuechter* ***17***: 451- 456.

Gardner, C.O. 1961. An evaluation of effects of mass selection and seed irradiation with thermal neutrons on yield of corn. *Crop Sci.* ***1***: 241-245.

Gardner, C.O. 1969. The role of mass selection and mutagenic treatment in modern corn breeding. In *Proceedings of the 24th Corn Research Conference*, American Seed Trade Association. pp. 15-21.

Gardner, C.O. 1977. Quantitative genetic studies and population improvement in maize and sorghum. In *Proc. Int. Conf. Quant. Genet* (Pollak, E, O. Kempthorne and T.B. Bailey Eds.). Iowa State Univ. Press, Ames, IA. pp 475-489.

Gomez, K.A. and A.A. Gomez.1984. *Statistical procedures for agricultural research*. 2nd ed., International Rice Research Institute, College, Laguna, 680p.

Hallauer, A.R., M.J. Carena and J. D. Miranda Filho 2010. *Quantitative genetics in maize breeding.* Vol. 6. Springer, New York.

Jasa-Vega, P.J. 1985. Divergent mass selection for line two synthetic reported in a maize (*Zea mays* L.) population. *Disser. Abst. International* ***45(11)***: 3422.

Johnson, E.C. 1963. Mass selection of yield in a tropical corn variety. *Amer. Soc. Agron. Abstr.* 82p.

Khan, M.S. 1983. Improvement of a population of maize (*Zea mays* L.) for Pakistan. *Disser. Abst. International* ***43(7):***2072

Lonnquist, J.H. 1967. Mass selection for prolificacy in corn. *Der Zuchter* ***37***: 185-188.

Mareck, J.H. and C.O. Gardner 1979. Responses to mass selection in Maize and stability of resulting populations1. *Crop Sci* ***19***:779-783. DOI:10.2135/cropsci1979.0011183X0019000600 08x

Miles, J.W., J.W. Dudley, D.G. White and R.J. Lambert 1980. Improving corn population for grain yield and resistance to leaf blight and stalk Rot. *Crop Sci* ***20***: 247-251.

Odhiambo, M.O. and W.A. Compton 1987. Twenty cycles of divergent mass selection for seed size in corn. *Crop Sci* ***27***: 1113-1116.

Rahman, H., I.H. Khalil, N. Islam, Durrishahwar and A. Rafi 2007. Comparison of original and selected maize populations for grain yield traits. *Sarhad J. Agric* ***23***: 641-644.

Salazar, A.M. and A.R. Hallauer 1986. Divergent mass selection for ear length in maize. *Rev. Bras. Genet* ***9***: 281-294.

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

Subandi, W. 1990. Ten cycles of selection for prolificacy in a composite variety of maize. *Indonesian J. Crop Sci* ***5***: 1-11.

Taran, S.A., S. Nasibullah, M.A. Mian and H. Shah 2004. Genetic improvement through mass selection in maize (*Zea mays* L.). *J. App. Em. Sc* ***1***: 152-157.

Vargas, S., J.E. Molina, J.D. Galan and S.T. Cervantia 1982. Mass selection and genetic parameters in the maize variety Zac. *Agrociencia* ***48***: 93-105.

Vaz Patto, M.C., P.M. Moreira, N. Almeida, Z. Satovic and S. Pego 2008. Genetic diversity evolution through participatory maize breeding in Portugal. *Euphytica* ***161***: 283-291.

Zorilla, H.L. and P.L. Crane 1982. Evaluation of three cycles of fullsib family selection for yield in the Col us 02 variety of maize. *Crop Sci* ***22***: 10-12.