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Influence of Planting Ratios on Growth, Seed Yield and Quality in Single Cross Hybrid Maize; MAH 14-5 (*Zea mays* L.)

G. S. Anil Kumar, T. M. Ramanappa and R. Siddaraju
Department of Seed Science and Technology, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
E-mail: ramantm@gmail.com

Abstract

An investigation was carried out to optimize the planting ratios between female (CAL 1443) and male (CML 451) parents to maximize seed yield and quality of single cross hybrid maize, MAH 14-5 during *Summer* 2018. The study consisted of five planting ratio of male and female with zinc application at the time of sowing. Planting ratios, zinc nutrient and their interaction showed non-significant differences for growth parameters *viz.,* plant height, number of leaves per plant, days taken to 50 and 100 per cent tasseling and silking in male and female respectively. The planting ratio of 4:2 significantly recorded maximum ear weight (141.63g), ear diameter (4.65 cm), ear length (18.55 cm), number of seed rows per ear (16.13), number of seeds per row (28.13), seed weight per ear (115.75g) and seed yield per plant (135.49g) in seed parent but, 4:1 showed significantly higher seed yield per plot (8.96 kg) and seed yield per ha (35.10q). However, number of ears per plant and pith weight showed non-significant for planting ratios. Zinc nutrient and interaction of planting ratios and zinc nutrient showed non-significant for all the yield parameters. Quality parameters *viz.,* hundred seed weight, germination, seedling length, seedling dry weight, seedling vigour index I and seedling vigour index II showed non-significant differences for planting ratios, zinc nutrient and their interaction.

Keywords: Maize, Planting ratios, Single cross hybrid

Maize (*Zea mays* L.; 2n = 20) belongs to family *Poaceae,* is one of the most important and versatile cereal crop, next to wheat and rice. Being a C_4 plant, it is physiologically more efficient and has higher yield potential and wider adaptability over a range of environmental conditions. It is referred to as 'miracle crop' or the 'queen' of cereals. It has greater significance due to its demand for food, feed and industrial utilization (Anon., 2017).

In India, maize ranks third position among the important cereal crops next to rice, wheat with 24.17 million tonnes production grown on an area of 9.18 million ha with productivity of 2630 kg ha^{-1} (Anon., 2017). Karnataka is one of the leading maize producing states in the country grown in an area of 1.34 million ha and ranks second in production with 3.98 million tonnes and productivity of 2990 kg ha^{-1}. The average productivity in Karnataka is much higher than the national productivity. Area under maize cultivation is rapidly increasing in the state, because of suitable environment. Thus, it contributes to national production *(*Anon., 2017).

Apart from synchronization, the another important characteristic feature which helps in increasing the seed parent yield is through maintaining the optimum planting ratio. Without optimum planting ratio, seed yield of seed parent drastically reduced thus, increase in cost of production of hybrid seed. By maintaining the increased frequency of male lines could increase the seed yield per plant of seed parent but under higher the male to female ratio, seed yield of female parent (seed parent) per plot or per ha will reduce because of less female rows per unit area. Apart from this, the seed yield of seed parent per unit area can increase upto certain level by increasing frequency of female rows, but upon increasing the female rows yield may reduce due to lack of sufficient pollen to pollinate higher number of female rows. Thus optimum planting ratio should be maintained to get maximum seed yield per plant as well as per unit area.

For seed production in hybrid maize, detasseling is important aspect and it should be done in female line. Failure of detasseling in seed parent leads to self-pollinationthus detasseling should be done every morning before anther dehiscence in female parent and care should be taken not to damage the flag leaf while detasseling.

The new hybrid MAH 14-5 with parentage of CAL 1443 female parent and CML 451 male parent need optimization of planting ratio for maximum seed yield.

METHODOLOGY

The field experiment was carried out at National Seed Project, University of Agricultural Sciences, Bangalore, Karnataka during Summer 2018. The experimental site is located at latitude of 12^0 58' North, a longitude of 77^0 35' East and at an altitude of 930m above mean sea level. The soil is red sandy clay loam with slightly alkaline (pH 6.3).

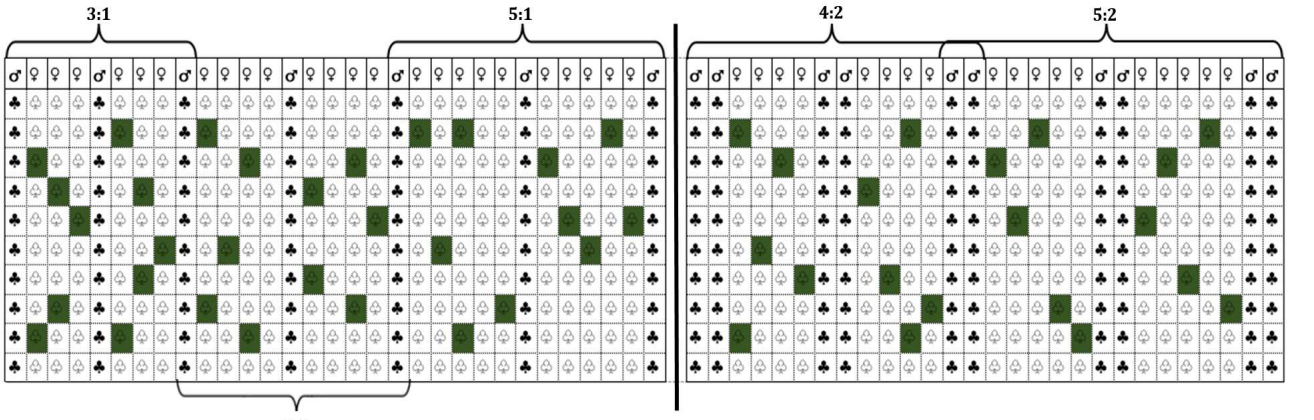
The experiment was laid out in split plot design with three replications, in which main plot treatments have planting ratios of P_1 (3:1, female to male), P_2 (4:1, female to male), P_3 (5:1, female to male), P_4 (4:2, female to male) and P_5 (5:2, female to male) and sub plot treatment have zinc nutrient (N) *i.e.,* with zinc nutrient (N_1) and without zinc nutrient (N_0).

Criteria for selection of data points for arriving at seed yield per plot

The male and female parents were sown in 3:1, 4:1, 5:1, 4:2 and 5:2 planting ratios and duplicated each ratio in three replications. A physical barrier has been put on between 5:1 and 4:2 planting ratios because of extra male line in 4:2. Considering 3:1 has a standard it had 9 rows each row had 10 plants thus total of 90 plants in an area of 3.0 m x 5.4 m. Irrespective of planting ratios, a total of nine rows of 10 plants each totalling 90 plants were considered for each ratio and calculated the frequency of female and male in that 90 plants.

In the ratio of 3:1, out of 90 plants 67 female and 23 male, in 4:1, 72 female and 18 male plants, in 5:1, 75 female and 15 plants male, 4:2, 60 female and 30 male and in 5:2, 64 female and 26 male plants.

Data was recorded on 10 competitive plants representing from all the rows. Out of the 10 plants,



Note:

- Area under 3:1 ratio is 3 m x 5.4 m. Taking this area constant for all.
- 3.0 x 5.4 sqmt occupies 90 plants. Hence, 90 plants are considered for comparing the yields of different ratios
- Of the 90 plants, the number of female and males for each ratio as under

Planting ratio	No. of Female	No. of Male
3:1	67	23
4:1	72	18
5:1	75	15
4:2	60	30
5:2	64	26

Fig. 1: Layout depicting the planting ratio and selection of data points for recording of observations to arrive seed yield per plot

50 per cent were selected from the neighbouring rows of male line and 50 per cent from the centre rows to rationalise the yield. The mean of the 10 plants was worked out to calculate the seed yield per plant. The seed yield per plot or unit area was calculated by multiplying the seed yield per plant with number female plants accommodated in each ratio. A criterion for selection of data points is depicted in Fig. 1.

The germination was tested as per the procedure outlined by ISTA., 2013, seedling length and seedling vigour index was calculated as per the Abdul Baki and Anderson (1973). The data collected from the experiment were analysed statistically by the procedure prescribed by Sundarraj *et al.* (1972). Critical differences were calculated at 5 per cent level whenever 'F' test was significant.

Results and Discussion

The planting ratios, zinc nutrient and their interactions showed non-significant differences for growth parameters *viz.,* plant height, number of leaves per plant, days taken to 50 and 100 per cent tasseling and silking in male and female, respectively. However, zinc nutrient recorded maximum values compared to that of without zinc nutrient.

Planting ratio of P_4 (4:2, female to male) was significant with ear weight (141.63 g), ear diameter (4.65 cm), ear length (18.55 cm), number of seed rows per ear (16.13), number of seeds per row (28.13), seed weight per ear (115.75 g), and seed yield per plant (135.49 g) in seed parent. While, number of ears per plant and pith showed non-significant differences for planting ratios but planting ratio 4:1 recorded significantly higher seed yield per plot (8.96 kg) and seed yield per ha (35.10 q). While zinc nutrient and interaction of planting ratios and zinc nutrient showed non-significant for above all yield parameters. However, with zinc nutrient showed maximum values for ear weight (135.84 g), ear diameter (4.47 cm), ear length (17.33 cm), number of seed rows per ear (15.04), number of seeds per row (25.86), seed weight per ear (110.33 g), seed yield per plant (125.14 g), seed yield per plot (8.43kg) and seed yield per ha (33.04 q). Planting ratios, zinc nutrient and their interaction was non-significant for quality parameters. However P_2 4:2 observed maximum values for hundred seed weight (32.30 g), germination (82.17 %), seedling length (31.83 cm), mean seedling dry weight (1050 mg), seedling vigour index I (2632) and seedling vigour index II (7965), while zinc nutrient recorded highest values compared to without zinc *i.e.,* hundred seed weight (31.33 g), germination (81.17 %), seedling length (29.68 cm), mean seedling dry weight (940 mg), seedling vigour index I (2442) and seedling vigour index II (7083).

Planting ratio P_4 (4:2, female to male), recorded maximum seed yield per plant which was due to availability of abundant pollen. For every four lines of female parent, there were two male lines, thus male lines produce bountiful pollen grains so that female parent has maximum accessibility to these pollen grains which fertilize female parent. Hence, the female lines in the ratio exhibited higher values for all the above parameters compare to the other planting ratios which have more female lines for each male line. But seed yield per plot and seed yield per ha, P_2 (4:1) showed significantly higher value compare to the other planting ratios. In the planting ratio, 4:1 the per plant yield was low compared to the per plant yield of female either in 3:1 or 4:2 planting ratios, but the proportion of the female plants in 4:1, are more in frequency compared to 3:1 or 4:2. In planting ratio 4:1, the number of yield contributing female plants per unit area is more in frequency *i.e.,* 72 compare to either in 3:1(67) or 4:2 (60). Despite the marginal low per plant yield in 4:1 ratio compare to 4:2, accommodates more number of female plants per unit area. Thus because of higher number of female plants and per plant yield of 4:1 ratio recorded higher per plot and per ha seed yield. Similar results were noticed by Vinutha (2014), Shashibhaskar (2012), Venkatesh *et al*. (2017), Abo-youssef *et al*. (2017) and Sharnkumar & Merwade (2013) in pearl millet.

TABLE 1

Effect of planting ratios (P) and zinc nutrition (N) on growth parameters of single cross hybrid maize MAH 14-5

Treatments	Plant height (cm)	Number of leaves per plant	Days taken to 50 per cent silking in female	Days taken to 100 per centsilking in female	Days taken to 50 per cent tasseling in male	Days taken to 100 per cent tasseling in male
			Main plot (planting ratios)			
P_1(3:1)	163.89	14.10	65.33	68.17	65.17	68.50
P_2(4:1)	167.34	13.78	65.17	68.17	65.33	68.17
P_3(5:1)	162.86	14.03	65.67	68.83	65.83	68.17
P_4(4:2)	161.35	13.83	65.50	68.50	65.50	68.50
P_5(5:2)	164.87	13.77	65.50	68.67	65.50	67.83
S.Em±	2.79	0.19	0.45	0.46	0.29	0.18
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Sub plot (Zn nutrient)			
N_1(With Zn)	164.84	14.00	65.33	68.25	65.42	68.25
N_0 (Without Zn)	162.89	13.88	65.50	68.58	65.50	68.42
S.Em±	1.70	0.09	0.19	0.16	0.15	0.15
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Interaction			
P_1N_1	162.85	14.33	65.11	67.67	65.00	68.00
P_1N_0	164.94	13.87	65.67	68.67	65.43	69.00
P_2N_1	168.31	13.90	65.33	68.33	65.35	68.02
P_2N_0	166.38	13.67	65.00	68.00	65.33	68.33
P_3N_1	166.86	14.03	65.33	68.33	65.67	68.30
P_3N_0	158.87	14.03	66.00	69.33	66.00	68.00
P_4N_1	161.34	13.73	65.67	68.67	65.67	68.67
P_4N_0	161.37	13.93	65.33	68.33	65.30	68.35
P_5N_1	161.31	13.93	65.67	68.67	65.67	68.05
P_5N_0	168.44	13.60	65.33	68.67	65.31	67.67
			Diff. levels of P means at the different levels of N			
S.Em±	4.71	0.28	0.63	0.58	0.44	0.38
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	10.01	10.57	7.15	8.88	7.88	9.85

TABLE 2

Effect of planting ratios (P) and zinc nutrition (N) on yield parameters of single cross hybrid maize MAH 14-5

Treatments	Number of ears per plant	Ear weight (g)	Ear diameter (cm)	Ear length (cm)	Pith weight (g)	Number of rows per ear
			Main plot (planting ratios)			
P_1(3:1)	1.53	139.70	4.47	18.28	25.77	16.00
P_2(4:1)	1.47	138.55	4.40	17.55	25.68	15.60
P_3(5:1)	1.60	122.28	4.32	14.58	24.23	12.37
P_4(4:2)	1.62	141.63	4.65	18.55	25.88	16.13
P_5(5:2)	1.53	130.28	4.24	16.57	24.55	12.95
S.Em±	0.06	1.03	0.06	0.25	0.46	0.30
CD (P=0.05)	NS	3.37	0.21	0.83	NS	0.96
			Sub plot (Zn nutrient)			
N_1(With Zn)	1.43	135.84	4.47	17.33	25.52	15.04
N_0 (Without Zn)	1.32	135.24	4.45	17.16	25.27	15.01
S.Em±	0.05	0.86	0.04	0.15	0.23	0.21
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Interaction			
P_1N_1	1.37	139.97	4.49	18.00	25.73	16.00
P_1N_0	1.40	139.43	4.45	18.57	25.80	16.00
P_2N_1	1.47	138.70	4.38	17.77	26.00	15.47
P_2N_0	1.27	138.40	4.42	17.33	25.37	15.73
P_3N_1	1.33	122.30	4.33	14.60	24.30	12.43
P_3N_0	1.13	122.27	4.31	14.57	24.17	12.30
P_4N_1	1.53	142.40	4.71	18.93	26.03	16.27
P_4N_0	1.47	140.87	4.60	18.17	25.73	16.00
P_5N_1	1.27	130.47	4.30	16.90	23.83	13.03
P_5N_0	1.33	130.10	4.18	16.23	25.27	12.87
			Diff. levels of P means at the different levels of N			
S.Em±	0.13	2.19	0.12	0.42	0.68	0.56
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	13.39	2.48	10.78	8.36	9.46	10.58

TABLE 3

Effect of planting ratios (P) and zinc nutrition (N) on yield parameters of single cross hybrid maize MAH 14-5

Treatments	Number of seeds per row	Seed weight per ear (g)	Seed yield per plant (g)	Seed yield per plot (kg)	Seed yield per ha (q)
			Main plot (planting ratios)		
P_1(3:1)	27.28	113.93	127.72	8.56	33.54
P_2(4:1)	26.47	112.87	124.38	8.96	35.10
P_3(5:1)	21.37	98.05	104.26	7.65	29.99
P_4(4:2)	28.13	115.75	135.49	8.13	31.86
P_5(5:2)	24.03	101.07	111.09	7.11	27.87
S.Em±	0.36	1.30	5.12	0.34	1.33
CD (P=0.05)	1.17	4.23	16.68	1.10	4.33
			Sub plot (Zn nutrient)		
N_1(With Zn)	25.86	110.33	125.14	8.43	33.04
N_0 (Without Zn)	25.82	109.98	120.78	8.22	32.21
S.Em±	0.26	0.58	2.99	0.19	0.75
CD (P=0.05)	NS	NS	NS	NS	NS
			Interaction		
P_1N_1	26.83	114.23	126.17	8.45	33.13
P_1N_0	27.53	113.63	129.27	8.66	33.95
P_2N_1	26.80	112.70	135.35	9.75	38.20
P_2N_0	26.13	113.03	113.41	8.17	32.00
P_3N_1	22.00	98.00	100.46	7.20	28.23
P_3N_0	20.73	98.10	108.05	8.10	31.76
P_4N_1	27.60	116.37	138.59	8.32	32.59
P_4N_0	28.17	115.13	132.39	7.94	31.13
P_5N_1	24.23	101.63	114.93	7.36	28.83
P_5N_0	23.83	100.50	107.25	6.86	26.90
			Diff. levels of P means at the different levels of N		
S.Em±	0.68	1.83	8.42	0.54	2.13
CD (P=0.05)	NS	NS	NS	NS	NS
CV (%)	9.91	10.07	12.73	12.44	10.13

TABLE 4

Effect of planting ratios (P) and zinc nutrition (N) on quality parameters of single cross hybrid maize MAH 14-5

Treatments	100 seed weight (g)	Germination	Seedling length (cm)	Mean seedling dry weight (g)	Seedling vigour index-I	Seedling vigour index-II
			Main plot (planting ratios)			
P_1(3:1)	30.83	81.17	28.42	920	2395	7011
P_2(4:1)	30.58	80.83	28.14	890	2329	6829
P_3(5:1)	30.12	79.67	27.04	750	2232	5898
P_4(4:2)	32.30	82.17	31.83	1050	2632	7965
P_5(5:2)	29.93	80.17	27.60	830	2308	6775
S.Em±	0.50	0.60	1.24	0.03	80.42	407.84
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Sub plot (Zn nutrient)			
N_1(With Zn)	31.33	81.17	29.68	940	2442	7083
N_0 (Without Zn)	30.58	80.75	28.03	860	2352	6769
S.Em±	0.46	0.26	0.61	0.020	56.65	122.59
CD (P=0.05)	NS	NS	NS	NS	NS	NS
			Interaction			
P_1N_1	31.23	82.00	29.60	1020	2371	6938
P_1N_0	30.43	80.33	27.23	820	2418	7085
P_2N_1	31.43	82.67	28.63	920	2343	7010
P_2N_0	29.73	79.00	27.65	860	2315	6648
P_3N_1	30.63	80.33	26.40	740	2358	6025
P_3N_0	29.60	79.00	27.68	750	2105	5772
P_4N_1	32.03	79.67	34.10	1080	2694	8361
P_4N_0	32.57	84.67	29.56	1020	2569	7569
P_5N_1	30.00	80.67	27.90	920	2179	6845
P_5N_0	29.87	79.67	27.31	740	2438	6704
			Diff. levels of P means at the different levels of N			
S.Em±	1.14	0.83	1.84	0.05	150.04	491.40
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	5.76	5.23	6.22	6.23	5.15	5.61

The study could be concluded that, planting ratio of 4:1 (female to male) in maize hybrid, MAH 14-5 has to be followed to register the maximum seed yield and quality.

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