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# Optimum Row Ratio for Seed Production of Single Cross Maize Hybrid, Karimnagar Makka-1 for Enhanced Yield and Profitability

**G. Manjulatha[1]*, E. Rajanikanth[2] and D. Sravani[3]**

***[1,&3] Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Karimnagar 505 001, Telangana, India***
***[2]Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Jagtial 505 529, Telangana, India***

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**ABSTRACT**

This study undertaken during rabi season of 2017 and 2018 at Agricultural Research Station, Karimnagar, Telangana to study the effect of planting row ratios of female: male for seed production of Maize hybrid Karimnagar makka-1. The flowering showed that male inbred has taken 60 days after sowing (DAS) to 50% pollen shedding as against 64 days in both 4:1 and 5:1 row ratios and female showed 50% silking at 63 DAS compared to 66 days in both 4:1 and 5:1 row ratios. The 5:1 row ratio recorded significantly more cob length (18.3 cm). Kernel number (29.5), 100-seed weight (39.3g), grain weight per cob (107.6g), seed yield of (2597 Kg/ha) and net returns (Rs. 3,93,632/ha) compared to 4:1 row ratio (17.9 cm, 27.3, 36.6 g, 99 g, 2094 Kg/ha and Rs. 3,05,132 / ha respectively) indicating 19.3 and 22.5% increased yield and net returns over 4:1 row ratio which in turn resulted significantly higher yield over 3:1 row ratio.

***Key words:*** *Maize, Female: Male row ratio, Flowering, Seed yield, Net returns*

## Introduction

Maize (*Zea mays* L.) is one of the most significant crop world wide used as food, fodder, vitamin source and industrial base material. It is considered as miracle crop popularly known as queen of cereals because of high yield potential and is one of the valuable agricultural plants whose diversity, adoptability and great nutritional value makes it one of the most important agricultural plant in the world. Globally it is a leading cereal crop in terms of area 193.73 million ha, production of 1147.62 million tons and productivity of 5.92 t/ha. It can play a vital role in ensuring food and nutritional security for India and world as a whole. Maize accounts for 15% of worlds proteins and 19% of the calories derived from food crops. In India maize is cultivated in 9.4 m ha with production of 28.1 millon tons and productivity of 3.07 t/ha (Anonymous, 2020). In Telangana state, maize occupied an area of 5.54 lakh hectares with production of 25.6 lakh tons and productivity of 4.60 t/ha. and is one of the important crop grown in Northern Telangana zone in which Karimnagar district is the major seed producing hub of the state occupying major area in seed production of maize and various other crops, owing to congenial climatic conditions, about 40,000 hactares area is under maize hybrid seed production, mostly in rabi season. As the seed hub of the country harbouring many a seed companies, the state is recognized as

one of the major maize hybrid seed production centres of the country.

Hybrid development programme of maize in India has been very dynamic. Single cross hybrid breeding has been adopted to enhance productivity across wide range of production ecologies. The accecptible solution for increasing productivity in hybrid seed production and subsequently economic self sufficiency is increasing yield per unit surface area. In addition there is need for research in optimum exploitation of seed producing areas so as to increase the production of seed. In maize, single cross hybrid seed production is challenging due to less yield of inbred parents and is further influenced by several agronomic and management factors among which time/spatial isolation requirements, level of nitrogen, staggered sowing, appropriate planting ratio, detasselling, skilled labour requirement are important to enhance seed yield per unit area (Khajepoor, 2000). Among these, one of the prime factor to make hybrid seed production more economical is the optimum row ratios of male and female parental lines so as to provide sufficient quantity of viable pollen to the seed parent during flowering period for ensuring increased pollination and fertilization to obtain higher hybrid seed set and yield (Jithendra *et al,* 2013). One of the causes of low seed yield in hybrid maize seed production is the lack of verified knowledge on the appropriate row ratio of male and female parents. In this context, the present investigation was undertaken to standardize the optimum row ratios for production of higher seed yield of Karimnagar makka-1, which is the medium maturity hybrid tolerant to late wilt released and notified from ARS, Karimnagar for the states of Telangana and Andhra pradesh.

## Materials and Methods

The field experiment was conducted at Agricultural Research Station, Karimnagar, Telangana state during *Rabi,* 2017-18 and 2018-19 with objective to find out the suitable row ratio for seed production of single cross maize hybrid Karimnagar makka 1. The experimental site is geographically situated at $18^0$26'N latitude and $79^0$ 5' E longitude and altitude of 229 m above mean sea level. It is covered under semi arid tropical climate with dry, hot summer and cool winters with an average annual rainfall of 1190 mm, most of which falls from June to October. This experiment is carried out in rabi season as it is favourable season for seed production. The overall weather conditions during rabi from November to February were quite favourable for the growth and seed production. During the years of experimentation, the mean minimum and maximum temperatures ranged from 14.4 to 22.4 $^oC$ and 30.6 to 35.5 $^oC$ and received rainfall of 4.4 and 53.2 mm in 1 and 5 rainy days respectively during 2017-18 and 2018-19. The soil of the experimental field was red sandy loam in texture and good in soil fertility status. The initial soil fertility status of the experimental soil has pH 6.86 (normal), EC 0.26 dS/m (non saline), organic carbon 0.41% (low), Available N 263 Kg/ha (low), available $P_2O_5$ 59 Kg/ha (high), available $K_2O$ 448 Kg/ha (high), available sulphur 56.3 mg/Kg (high) and available iron, copper, manganese, zinc and boran are 4.66, 0.50, 9.86, 1.05 and 0.32 PPM respectively are all in adequate quantities.

The experiment was conducted in Randomized block design with three different row ratios of female : male as T1. 3 : 1 Row ratio, T2. 4 : 1 row ratio, T3. 5 : 1 row ratio, in seven replications. The female inbred parent is PFSR 1 and Male inbred parent is BML 7 of Maize hybrid Karimnagar makka 1. Sowing was done by dibbing manually as per the treatmental row ratios of male and female seed with two seeds per hill at a spacing of row to row as 60 cm and plant to plant distance of 20 cm using 20 kg seed per hectare, finally the plants were thinned to single plant/hill to have the desired plant population. Intercultivations was carried out twice with bullock drawn guntaka and earthing up done. The recommended dose of fertilizer was 240-60-50 kg N - $P_2O_5$ - $K_2O$ per hectare. The N, P and K were applied through urea (46% N), single super phosphate (16% P) and muriate of potash (60% K). The full dose of phosphorus and and 1/3 dose of nitrogen and ½ dose of Potassium were applied at the time of sowing as basal application, whereas the remaining dose of nitrogen was applied in two equal splits at knee high and tasseling stage along with half dose of potassium. The tassel of the female lines was removed as they came out from the plant to aid in fertilization of female parent plants from the pollen of male parent. Five plants in each treatment and replication were randomly selected and tagged for recording the growth and yield attributes at the time of flowering and harvesting. The economic returns were compared by calculating the Net returns and Benefit cost ratio for different row ratios. The cost of

cultivation is worked out based on prevailing rates. The sale price of maize seed for calculation of returns is Rs. 180/Kg seed. The data obtained from various periodical observations were subjected to statistical analysis. The analysis of variance and interpretation of data were done as per procedure given by Gomez and Gomez (1984). The experimental data obtained were pooled for two years was subjected to the analysis of variance for test of significance using standard procedure.

## Results and Disscussion

**Effect of row ratios on Crop Growth :** The evaluation of effect of row ratios on seed production of maize hybrid Karimnagar makka 1 indicated that growth parameters as plant and ear height at harvest did not differ significantly with different row ratios of 3:1, 4:1 and 5:1 female: male planting row ratios as presented in Fig. 1. Among the row ratios , the 5:1 row ratio recorded neumerically more plant height in both female and male inbreds (154.4 and 168.8 cm respectively) over 4:1 row ratio (153.4 and 165.4 cm respectively) and consequently 3:1 row ratio resulted in relatively lower plant height at harvest (142.5 and 154.3 cm respectively). The Ear height at harvest similarly observed higher with 5:1 row ratio I both female and male inbreds (74.4 and 63.9 cm respectively) as against the 4:1 (73.2 and 62.9 cm respectively) and 3:1 row ratio (69.9 and 61.9 cm respectively). These results showed that unlike 3:1 row ratio, the 4:1 and 5:1 row ratio had shown good response in registering higher plant and ear height which determine the source to sink relationship. It is observed that row ratio did not exert significant influence on plant and ear height parameters studied. It may be perhaps to the fact that arrangement of row ratio is a mere agronomic manipulation rather than a technique or practice and hence it has shown non significant statistical effect (Sharankumar and Merwade, 2013). These results are in conformity with earlier results of Kathavate, 1967., Veeranagoudar, 1999 and Venkatesh *et al*. 2017). Further Sharankumar and Merwade, 2013 also revealed non significant differences on growth parameters like plant height, leaf number, leaf area, leaf area index and crop maturity due to 4:2 and 6:2 planting ratios in both the years of experimentation.
**Effect of row ratios on Flowering :** Days to 50% pollen shedding of male and days to 50% silking in female inbred shown that 5:1 and 4:1 female to male row ratio recorded non significant variation i.e., similar flowering behavior is observed. The 3:1 row ratio resulted in significantly early flowering in both male and female inbreds as compared to 4:1 and 5:1 row ratios. The male inbred has taken 60 days after sowing to 50% pollen shedding in 3:1 row ratio as against 64 days in both 4:1 and 5:1 row ratios and female inbred had 50% silking at 63 days after sowing in 3:1 row ratio compared to 66 days in both 4:1 and 5:1 row ratios (Fig. 1). The similar findings on flowering parameters due to planting ratios were also reported by Patil and Goud, 1980, Patil and Bhard, 1991 and Veeranagoudar, 1999.

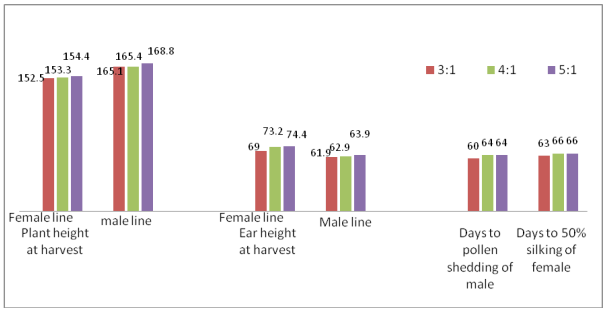


**Fig. 1.** Graph showing the Plant and Ear height and flowering in male and female inbred lines of maize hybrid Karimnagar makka 1.

**Effect of row ratios on Yield Components :** The effect of different planting row ratios of female parental line (PFSR 3) was significant on yield attributes of cob length, kernel no./cob, 100-seed weight and grain weight/cob (Table 1). The cob length recorded significantly higher in 5:1 row ratio (18.3 cm) as compared to 4:1 row ratio (17.9 cm) which inturn recorded significantly higher over 3:1 row ratio (15.5 cm). The ear diameter did not exert meaningful difference between the row ratios. Neumarically the ear diameter resulted highest in 5:1 row ratio (41.4 mm) over 4:1 (37.1 mm) and 3:1 row ratio (36.8 mm). However, the kernel no./cob observed to be significantly affected by row ratios. The results shown that kernel no./cob were significantly higher with 5:1 row ratio (29.5) as compared to 4:1 row ratio (27.3) and which recorded significantly higher kernels per cob over 3:1 row ratio (23.7). While, the kernel rows per cob resulted non significant with row ratios. There was meaningful difference in terms of row ratios for grain weight per cob of female inbred line, such that significantly maximum grain weight per cob is obtained with 5:1 row ratio (107.6 g) followed by 4:1 row ratio (99 g) which inturn recorded signifi-

cantly higher over 3:1 row ratio (93.2 g). The possible reason for significantly higher cob length, kernel number per cob, grain weight per cob may be attributed that the produced pollens were more and that led to increase in the insemination power of pollen which consequently increased the fertility rate and filling up of ears and as well as transfer of photosynthate substances towards the grain which inturn led to significant difference in the 100-seed weight with different row ratios. In the similar way, the 100-seed weight also observed to be significantly higher in 5:1 row ratio (39.3 g) over 4:1 row ratio (36.6 g) and which inturn noticed to be higher as compared to 3:1 row ratio (35.5 g). The found results were supported by similar research by Aryannia et al, 2011, where male – female ratio gave significant influence towards productivity –supporting characters such as early cob weight, fresh threshed weight, dry threshed weight, No. of kernels per cob and comparison percentage of seed and cob.

The effect of different planting row ratios of male parental line (BML 7) was significant on yield attributes of cob length, 100-seed weight and grain weight/cob. While, ear diameter, kernel rows and no./cob and single cob weight were non significant for male inbred line (Manjulatha and Sumalini, 2021). The cob length recorded significantly higher with 5:1 row ratio (18.2cm) and is on par with 4:1 row ratio (17.6 cm). The grain weight/cob and 100-seed weight also followed the similar trend (Table 2). The similar findings on yield components of male line due to planting ratios were also reported by Patil and Bhard, 1991.

**Effect of row ratios on Hybrid seed yield :** It is seen that significantly higher Female seed yield of 2597 Kg/ha was recorded with 5:1 row ratio as compared to 4:1 row ratio (2094 Kg/ha), which is 19.3% increase over 4:1 row ratio . This inturn resulted in significantly higher seed yield over 3:1 row ratio (1603 Kg/ha) which accounts to 23.4% increase as compared to 3:1 row ratio (Table 1). The cob yield also followed the similar trend and results showed that 5:1 row ratio resulted in significantly higher female cob yield of 3039 Kg/ha, which is 12.6% increase as compared to 4:1 row ratio (2656 Kg/ha) , which inturn recorded 26% higher cob yield over 3:1 row ratio (1965 Kg/ha). Sirih *et al.,* 2021 also reported that the planting ratio of 6:1 was able to increase the yield of hybrid corn seed production. Similar results was also reported by Afsharmanesh *et al.,* 2020. Significantly higher yield in 5:1 female-male row ratio is attributed to significant increase in yield components i.e., cob length, kernel number per cob, grain weight per cob and 100-seed weight as is evident from the results of this study (Table 1). The increased hybrid seed yield per hectare noticed in 5:1 and 4:1 row ratios may also be related to availability of more effective pollinating space and high viable pollens from male parent to the female parent during flowering period and it resulted in higher hybrid seed setting and hybrid seed yield. As we all know that seed production are mainly done with detasseling in order to avoid self pollination. The moderate width of detasseling in female-male row ratio resulted in more effective pollination which might be attributed to pollen dispersing angle not limited to close proximity of male and female flowers. Further detasseling also increases assimilation towards the cob in female inbred parent. Therefore, productivity from 5:1 row ratio was preferred than 4:1 or 3:1 row ratio (Ridwan *et al.,* 2020). This was supported by Chamecki *et al.,* 2011. Another evident reason for increased yield in 5:1 row ratio over 4:1 row ratio and 4:1 row ratio as compared to 3:1 row ratio is attributed to increased maternal population by 85% in 5:1 female-male row ratio and 80% under

**Table 1.** Effect of Row Ratios on Yield, yield attributes and Economics of Female inbred , PFSR 3 for Karimnagar makka 1, hybrid seed production (pooled for two years)

| Female: Male Row ratios | Grain yield (Kg/ha) | Cob yield (Kg/ha) | Cob length (cm) | Ear Diameter (mm) | Kernal rows/ cob | Kernal no./ row | Single cob wt (g) | Grain wt/cob (g) | 100-Grain eweight (g) | Net returns (Rs./ha) | B: C Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3:1 | 1603 | 1965 | 15.5 | 36.8 | 13.6 | 23.7 | 123.2 | 93.2 | 35.5 | 2,18,299 | 3.72 |
| 4:1 | 2094 | 2656 | 17.9 | 37.1 | 14.6 | 27.3 | 129.4 | 99.0 | 36.6 | 3,05,132 | 4.81 |
| 5:1 | 2597 | 3039 | 18.3 | 41.4 | 15.0 | 29.5 | 130.6 | 107.6 | 39.3 | 3,93,632 | 5.91 |
| S.Em.+ | 45.6 | 47.1 | 0.56 | 2.1 | 0.4 | 1.5 | 4.9 | 1.51 | 0.7 | 8310 | 0.1 |
| C.D (0.05) | 142.1 | 146.7 | 1.13 | NS | NS | 4.5 | NS | 4.7 | 2.1 | 25,889 | 0.32 |
| C.V (%) | 9.7 | 9.6 | 8.52 | 5.1 | 9.6 | 7.32 | 10.2 | 5.9 | 7.6 | 7.2 | 8.7 |

**Table 2.** Effect of Row Ratios on Yield, yield attributes and Economics of Male inbred, BML 7 for Karimnagar makka 1, hybrid seed production (pooled for two years)

| Female: Male Row ratios | Grain yield (Kg/ha) | Cob yield (Kg/ha) | Cob length (cm) | Ear diameter (mm) | Kernal rows/ cob | Kernal no./ row | Single cob weight (g) | Grain weight/ cob (g) | 100-grain weight (g) |
|---|---|---|---|---|---|---|---|---|---|
| 3:1 | 582 | 766 | 15.5 | 35.3 | 13.6 | 27.1 | 127.4 | 94.2 | 26.7 |
| 4:1 | 491 | 628 | 17.6 | 41.6 | 14.4 | 28.5 | 134.0 | 104.2 | 29.5 |
| 5:1 | 371 | 473 | 18.2 | 42.2 | 14.4 | 29.4 | 150.8 | 107.6 | 30.4 |
| S.Em.+ | 67.5 | 72.5 | 0.55 | 2.6 | 0.25 | 2.5 | 8.1 | 1.35 | 0.33 |
| C.D (0.05) | 155.9 | 191.8 | 1.73 | NS | NS | NS | NS | 4.2 | 1.02 |
| C.V (%) | 12.7 | 10.2 | 8.57 | 6.4 | 6.2 | 7.4 | 11.3 | 8.3 | 5.36 |

4:1 row ratio as compared to lowest female population in 3:1 row ratio with 75% than compared to male inbred parent population. Sharafizadeh *et al*. (2012) also reported the increase in grain yield with increase in maternal lines planted in an area. In contrary, the seed and cob yield of male inbred parent is significantly higher in 3:1 row ratio (582 and 766 Kg/ha) which is on par with that of 4:1 row ratio (491 and 628 Kg/ha) than compared to 5:1 row ratio (371 and 473 Kg/ha), respectively (Table 2). The higher seed and cob yield of male inbred in 3:1 row ratio is attributed to the more no. of paternal lines in 3:1 row ratio. Consequent to increase in maternal lines in 5:1 row ratio the seed and cob yield of male line decreased (Singh and Singh, 2006).

**Effect of row ratios on Economic Returns:** The data presented showed that net returns of maize hybrid seed production with different row ratios differed significantly. The 5:1 female-male row ratio recorded significantly higher net returns (Rs. 3,93,632 /ha) indicating 22.5% increased returns over 4:1 row ratio (Rs. 3,05,132/ha) which inturn recorded higher returns as compared to 3:1 female-male row ratio (Rs. 2,18,299/ha). Obviously, the benefit to cost ratio also resulted significantly higher with 5:1 row ratio (5.91) with 18.6% higher profits over 4:1 row ratio (4.81) which inturn recorded higher B:C ratio as compared to 3:1 row ratio (3.72). The high returns and profits is attributed to higher seed yield with 5:1 female-male row ratio as compared to 4:1 and 3:1 row ratio which fetched higher economic returns.

Based on two year study, it can be concluded that, to increase the yield for seed production of maize hybrid Karimnagar makka 1, planting of 5 : 1 female (PFSR 3) – male (BML 7) row ratio resulted in significantly highest hybrid seed yield, so 5 :1 planting ratio can be recommended to achieve higher hybrid yields and profits compared to recommended 4:1 planting ratio for single cross hybrid, Karimnagar makka-1.

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