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# Impact of Different Crop Geometry in Maize on Fall Armyworm, *Spodoptera frugiperda* Infestation

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***Abstract***: A field study was designed to investigate the impact of crop spacing and hybrids on the incidence of Fall armyworm in maize CoH(M)-6 and NK-6240 during *Rabi* season (2019) and the observations were made at fortnight intervals. The results revealed that NK-6240 hybrid maize sown at conventional sowing (dibbling method) showed maximum larval population ranged from 1.71 to 3.05 larvae/plant, infestation ranged from 56.73 to 74.21 % and leaf damage score was 6.6. The lowest larval population was observed on CoH(M)-6 maize plots sown at 60x25cm spacing, which ranged from 0.52 to 1.09 larvae/plant and per cent infestation was ranging from 23.14 to 53.32% and the mean damage score was significantly low (3.5) and resulted in significantly higher yield. However, in NK-6240 the grain yield was higher at 60x25cm spacing (10525 kg/ha) as compared to conventional sowing (6196 kg/ha). The different crop spacing had an impact on the fall armyworm incidence, leaf damage, plant infestation and yield loss. The hybrid CoH(M)-6 at 60x25cm spacing recorded minimum larval population, infestation and leaf damage score and yield loss.

***Keywords***: Maize, Fall armyworm, *Rabi*, Spacing, Larval population, Per cent infestation, Leaf damage, Yield

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) native to America is a key pest of maize, found in several countries including Mexico, Brazil, Argentina and USA (Clark *et al* 2007) and causes severe economic losses in variety of crops such as maize, soybean, cotton, rice and other grasses and feeds on number of weeds (Nabity et al 2011). Severe incidence of fall armyworm was reported from African countries such as Nigeria, Benin and Togo in 2016. The incursion of FAW as an invasive pest into Asia was reported for the first time from India on maize during May 2018. Since then, it has spread to different states cultivating maize (Sharanbasappa et al 2018). The spread of this pest to other Asian countries including Thailand, Sri Lanka, Bangladesh, Myanmar, Vietnam, Laos and China has occurred quickly (Wu et al 2019). Maize, *Zea mays* L. (Poaceae) is one of the most important staple crops in India, grown in an area of 9.2 million ha with the production of 27.8 million metric tonnes per year and productivity of 2965 kg/ha. In India, about 15 million farmers are engaged in maize cultivation and it generates employment for more than 650-million-person at farming and its related business ecosystem levels (FICCI 2018). Kharif maize represents around 80% of maize area while *rabi* maize represent 19% of area. Summer maize occupies 1-2% of total maize area in India. Out of three maize seasons nearly 80% of kharif maize is cultivated under rainfed condition, while *rabi* and summer maize is cultivated under assured irrigated ecosystem. In India, maize is cultivated throughout the year as grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products. The recent invasion of fall armyworm is a threat to the food security of India. The FAW larvae usually feed on the developing leaves in the funnel, creating a characteristic windowing effect and bore into the developing reproductive structures such as maize cobs, reducing yield quality and quantity (Bateman et al 2018).

Farmers have resorted to 4-5 sprays of different insecticides at high doses without the knowledge of their efficacy leads to quick development of resistance, negative impact on natural enemies and also causing accumulation of pesticides in the environment (Gutierrez et al 2019). t. Due to monoculture of maize, the fall armyworm infestation causes more and high pest buildup. This leads to chemical intensive agriculture is so much, that farmers resort to a minimum of 5 to 6 chemical sprays on maize, making cultivation of maize highly risky and non-profitable. In addition to this, overuse of pesticides has leads to resurgence of pests and ill effects on natural enemy fauna. Pesticide residues in maize are also of great concern from the point of domestic consumption and exports as well. It is therefore, imperative to find out a better spacing from the point of pest debilitation so that the crop can escape the pest attack or receives less pest ravage ultimately leading to reduced pesticide consumption and to become viable components of a sound IPM programme. In present study the management option for FAW is ecological pest management based on the utilization of crop spacing, which is sustainable, cost- effective and causes minimum risk to the humans and the environment.

## MATERIAL AND METHODS

The present investigation to determine the effect of different plant spacings against fall armyworm and yield of maize was conducted at Experimental farm, Agricultural College and Research Institute, Madurai situated between latitude 9.54º N and longitude 78.54º E. The area is semiarid with a mean annual rainfall of 890 mm and 147 meters from above mean sea level. Field trial was carried out during the year *rabi*, 2019 and 2020. Three different crop spacing were evaluated under three two hybrid maize varieties. Three crop spacings were selected based on (i) Precision farming (75x20 cm), (ii) TNAU recommended spacing (60x25cm) and Farmer's practice (45x30cm) was maintained by hand dibbler having a net plot size was 7m x 2m were evaluated against fall armyworm incidence and damage in comparison with check. Check was maintained by dibbling method using NK- 6240 irregular spacing. Each treatment was replicated four and each replication data was the mean of data obtained from 20 plants. The sowing was done with two region popular maize hybrids *viz.,* COH (M)-6 (TNAU) and NK – 6240 (Syngenta private ltd, India). All common standard agronomic cultural practices were followed in the experimental field except plant protection measures (Table 1).

The observations on larval population (Number of larvae /plant), leaf damage (damage severity) and per cent plant infestation along with yield were recorded. Larval population was observed by counting on number of larvae present per plant at fortnight intervals. The per cent plant infestation and leaf damage described by Davis and Williams (1992) was followed for this study; leaf damage was assessed based on scale rating 0 = no visible leaf damage, 1 = only pin-hole damage to the leaves, 2 = pinhole and shot-hole damage to leaves, 3 = small elongated lesions (5-10 mm) on 1-3 leaves, 4 = mid-sized lesions (10-30 mm) on 4-7 leaves, 5 = large elongated lesions (>30 mm) or small portions eaten on 3-5 leaves, 6 = elongated lesions (>30 mm) and large portions eaten on 3-5 leaves, 7 = elongated lesions (>30 cm) and 50% of leaf eaten, 8 = elongated lesions (30 cm) and large portions eaten on 70% of leaves, 9 = most leaves have long lesions and complete defoliation. The summary classification of leaf damage rating 0-4 = minimal visible leaf damage (low), 5-7= marginal leaf damage (medium) and 8-9= extensive leaf damage (high). The yield data were recorded for each treatment separately and grain yield was expressed in kg/ha. The data collected were subjected to statistical analysis of variance by SPSS software and means were compared with Tukey's test at P≤ 0.05.

**Table 1.** Treatments details

| Treatments | Spacing adopted | Hybrid used | Rows |
|---|---|---|---|
| $T_1$ | 75x20 cm | CoH(M)-6 | 9 rows |
| $T_2$ | 60x25 cm | CoH(M)-6 | 12 rows |
| $T_3$ | 45x30 cm | CoH(M)-6 | 15 rows |
| $T_4$ | 75x20 cm | NK-6240 | 9 rows |
| $T_5$ | 60x25 cm | NK-6240 | 12 rows |
| $T_6$ | 45x30 cm | NK-6240 | 15 rows |
| $T_7$ | Irregular spacing | NK-6240 | 10 rows |

## RESULTS AND DISCUSSION

The descending order of best spacing against *S. frugiperda* infestation were 60 x 25 cm followed by 75x20 and 45x30 cm. Between the two hybrids, COH(M)-6 hybrid performed better than NK- 6240. All the treatments were superior over the check in reducing larval population (Table 2). On 15 DAS, treatment COH(M)-6 at 60 x25cm recorded minimum larval population of 0.52 number per plant. The treatment with COH(M)-6 at 75x20 cm and NK- 6240 at 60x 25 cm recorded 0.70 larvae per plant which were statistically on par with conventional sowing (check) recorded maximum larval population (1.71 larvae/plant). On 30 DAS, the treatment COH(M)-6 at 60 x25cm recorded minimum population 0.63 larvae per plant followed by NK -6240 at 60 x25 cm and maximum larval population in conventional sowing (check) was 1.82 larvae per plant. On 45 DAS, the conventional sowing (check) recorded maximum larval population (2.70 larvae / plant). And in treatment COH(M)-6 at 60 x 25cm larval population was minimum (0.97 larvae/ plant). On 60 DAS and 75 DAS, the same trend was observed in various treatments. Akinkunmi et al (2012) recorded at high population in sunflower in the lowest spacing of 65cm x75. However, at wider spacing especially 100cm x 75cm there was a reduction in larval population. The mean larval population recorded on COH(M)-6 at 60x25 cm was minimum (0.72larvae/plant). NK-6240 at 60 x25 cm (1.03 larvae/plant) was on par with COH(M)-6 at 75x20 cm (1.05 larvae/ plant) followed by NK -6240 at 75 x20 cm , COH(M)-6 at 45x30 and NK -6240 at 45x30 cm . The larval population was the highest in check (conventional sowing) (2.27 larvae/plant). Warkad et al (2021) indicated that spacing at 60x25 cm recorded 0.99 fall armyworm larvae per plant in maize. All the treatments were superior over the check in reducing the infestation level (Table 3). On 15 DAS, treatment COH(M)-6 at 60x25cm (23.14%) recorded minimum infestation followed by NK -6240 at 60 x25 cm . followed by

COH(M)-6 at 75x20 cm, NK -6240 at 75 x20 cm. Conventional sowing (check) recorded maximum infestation (56.73%). The present findings were confirmed with the results of Phani Kumar et al (2021) where plant infestation at spacing 75 x 20 cm was 44.07 per cent by *S. frugiperda* on maize.

On 30 DAS, the treatment COH(M)-6 at 60 x 25 cm recorded minimum infestation of 34.31% and maximum infestation recorded in conventional sowing (61.82 %). On 45 DAS, the conventional sowing recorded peak infestation (72.62%) and the treatment COH(M)-6 at 60 x25cm recorded minimum infestation (50.16%). On 60 DAS and 75 DAS, the same trend was observed in different treatments. On 15 DAS, treatment COH(M)-6 at 60 x25cm recorded minimum leaf damage score (3.0) followed by NK -6240 at 60 x25 cm (3.6) (Table 3). The treatment with COH(M)-6 at 75x20 cm recorded a score of 4.5 followed by NK -6240 at 75 x20 cm (4.8), COH(M)-6 at 45x30 cm (4.9) and NK -6240 at 45x30 cm (5). Conventional sowing (check) recorded maximum leaf damage score (5.3). On 30 DAS, the treatment COH(M)-6 at 60 x25cm recorded the lowest leaf damage score of 3.4 and leaf damage recorded on conventional sowing (check) showed the highest leaf damage (6.0) and at 45, 60 and 75 DAS the conventional sowing recorded maximum leaf damage score varying from 7.2 to 8.0.The average mean leaf damage score in the conventional sowing (check) was (7.4). Among the other treatments, COH(M)-6 at 60 x25cm recorded the lowest leaf damage score (3.5) and other treatments in order of efficacy were COH(M)-6 at 60 x25 cm, COH(M)-6 at 75x20 cm, NK -6240 at75x20 cm, COH(M)-6 at 45x30 cm and NK -6240 at 45x30 cm Phani Kumar et al (2021). also reported that fall armyworm leaf damage score was 6.6 at 75x20 cm spacing in maize. Akinkunmi et al (2012) reported that the highest damaged leaves (48.60%, 51.25%),

**Table 2.** Impact of crop geometry and hybrid against fall armyworm larval population in maize, during *rabi* season (September-December 2019)

| Treatments | Larval population (No. of larvae/plant)$^{\#}$ | | | | | Average mean |
|---|---|---|---|---|---|---|
| | 1 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | |
| T$_1$ - CoH(M)-6 at 75 x 20 cm | 0.70$^{ab}$ | 0.85$^{ab}$ | 1.25$^{ab}$ | 1.39$^{ab}$ | 1.03$^{b}$ | 1.05$^{b}$ |
| T$_2$ - CoH(M)-6 at 60 x 25 cm | 0.52$^{a}$ | 0.63$^{a}$ | 0.97$^{a}$ | 0.89$^{a}$ | 0.55$^{a}$ | 0.72$^{a}$ |
| T$_3$ - CoH(M)-6 at 45 x 30 cm | 1.02$^{b}$c | 1.37$^{cd}$ | 2.16$^{cd}$ | 2.23$^{cd}$ | 1.82$^{d}$ | 1.72$^{d}$ |
| T$_4$ - NK-6240 at 75 x 20 cm | 0.80$^{ab}$ | 0.99$^{a}$ | 1.69$^{bc}$ | 1.86$^{bc}$ | 1.36$^{c}$ | 1.34$^{c}$ |
| T$_5$ - NK-6240 at 60 x 25 cm | 0.70$^{ab}$ | 0.78$^{a}$ | 1.50$^{ab}$ | 1.24$^{ab}$ | 0.93$^{d}$ | 1.03$^{b}$ |
| T$_6$ - NK-6240 at 45 x 30 cm | 1.27$^{c}$ | 1.51$^{ef}$ | 2.25$^{cd}$ | 2.26$^{e}$ | 1.91$^{e}$ | 1.84$^{d}$ |
| T$_7$ - Conventional sowing | 1.71$^{d}$ | 1.82$^{f}$ | 2.70$^{e}$ | 2.54$^{f}$ | 2.56$^{f}$ | 2.27$^{e}$ |

# Mean values of four replications; Means followed by the same letter (s) are not significantly different at p≤ 0.05 by Tukey's test; DAS – Days after sowing

**Table 3**. Impact of crop geometry and hybrid against fall armyworm infestation in maize, during *rabi* season (September-December 2019)

| Treatments | Per cent infestation on plant # | | | | | Average mean | Leaf damage score on infestation # | | | | | Average score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | |
| T$_1$ | 36.87$^{bc}$ | 42.40 | 57.90$^{abc}$ | 55.22$^{abc}$ | 38.94$^{ab}$ | 44.92$^{ab}$ | 4.5 (M) | 5.2 (M) | 5.8 (M) | 6.0 (M) | 4.9 (M) | 5.4 (M) |
| T$_2$ | 23.14$^{a}$ | 34.31$^{a}$ | 50.16$^{a}$ | 46.95$^{a}$ | 30.24$^{a}$ | 39.10$^{a}$ | 3.0 (L) | 3.4 (L) | 4.3 (M) | 4.1 (M) | 2.8 (L) | 3.5 (L) |
| T$_3$ | 46.17$^{de}$ | 51.78$^{cd}$ | 66.38$^{cde}$ | 61.80$^{bc}$ | 46.75$^{bc}$ | 53.84$^{cd}$ | 4.9 (M) | 5.8 (M) | 6.8 (M) | 7.0 (M) | 5.5 (M) | 6.0 (M) |
| T$_4$ | 39.75$^{cd}$ | 45.13$^{bc}$ | 61.81$^{bcd}$ | 58.04$^{abc}$ | 42.32$^{bc}$ | 48.30$^{bc}$ | 4.8 (M) | 5.4 (M) | 6.0 (M) | 6.5 (M) | 5.2 (M) | 5.6 (M) |
| T$_5$ | 29.81$^{ab}$ | 39.83$^{ab}$ | 54.98$^{ab}$ | 51.30$^{ab}$ | 33.39$^{a}$ | 44.20$^{ab}$ | 3.6 (L) | 4.7 (M) | 5.0 (M) | 5.2 (M) | 4.2 (M) | 4.5 (M) |
| T$_6$ | 50.46$^{ef}$ | 56.69$^{ef}$ | 69.03$^{de}$ | 64.47$^{e}$ | 50.88$^{cd}$ | 59.06$^{de}$ | 4.8 (M) | 5.9 (M) | 7.7 (M) | 7.6 (M) | 6.1 (M) | 6.6 (M) |
| T$_7$ | 56.73$^{f}$ | 61.82$^{f}$ | 72.62$^{f}$ | 66.44$^{e}$ | 55.87$^{d}$ | 62.70$^{e}$ | 5.3 (M) | 6.6 (M) | 8.2 (M) | 8.0 (M) | 7.2 (M) | 7.4 (M) |

See Table 1 for details

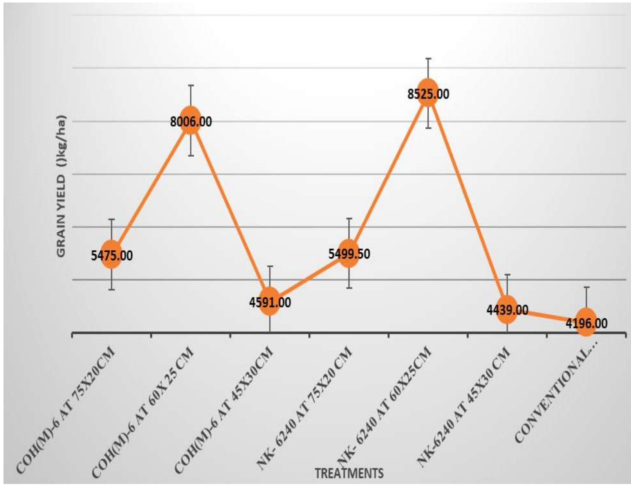


**Fig. 1.** Impact of crop geometry and hybrid on yield of maize during *Rabi* season (September 2020-December 2020)

stems (22.25%, 25.10%), and flower heads (23.50% and 27.20%) in 2009 and 2010 respectively in sunflower plants with 65 cm x 75 cm (high density) spacing while at low density spacing of 100cm x 75cm, the damage on the leaves, stem and flower head were significantly reduced.

The highest grain yield was in NK -6240 at 60 x25 cm (8525 kg/ha) which was on par with COH(M)-6 at 60 x25cm followed by NK -6240 at 75 x20 cm and COH(M)-6 at 75x20 cm The lowest grain yield was recorded in conventional sowing (4196 kg/ha). Moro et al (2016) reported higher grain yields under wider spacing (20 cm x 25 cm; 20 cm x 20 cm) than closer (20 cm x 15 cm; 15 cm x 15 cm, 30 cm x 10 cm) spacing in rice. Shranabasappa et al (2020) revealed that maize spacing of 45x30 cm (3,246 kg/ha) recorded lowest grain yield.

## CONCLUSION

This study provides valuable information about the impact of different crop geometry against fall armyworm and its infestation levels. CoH(M)-6 recorded minimum fall armyworm infestation and significantly higher yield at 60x 25 cm spacing. The FAW incidence is more in high plant density. During the *Rabi* season, the sowing of COH(M)-6 hybrid at 60x 25 cm can be included as one of the cultural components for integrated pest management of *S. frugiperda* in maize.

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