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Effect of land configuration and weed management practices on yield and yield attributes of hybrid maize (*Zea mays* L.) during *kharif* season

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Abstract
A field experiment was conducted at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh to assess the effect of land configuration and weed management practices and their interaction effect on growth of *kharif* maize for two consecutive years (2018 and 2019). The experiment comprises of three land configuration method as a main treatment *viz*; P_1-flat-bed planting, P_2-Ridge and furrow planting and P_3-Broad bed and furrow planting and six weed management practices were applied as sub treatment *viz*; W_1 -Pendimethalin @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post- emergence, W_2 -Atrazine @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post – emergence, W_3-Pendimethalin @ 1.0 kg ha^{-1} as pre- emergence + Halosulfuron methyl @ 67.5g. ha^{-1} at 15-20 DAS as post – emergence + one hand weeding at 45 DAS, W_4-Atrazine @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post – emergence + one hand weeding at 45 DAS, W_5- Weed free and W_6 -Weedy check making eighteen treatment combination which was assigned in a Split Plot Design (SPD) replicated thrice. Hybrid maize variety (DKC –7074) was grown with the recommended agronomic practices. Results showed that maximum increase in yield attributing characters *viz*: number of cob plant^{-1}, cob length (cm.), cob weight (g.), cob girth (cm.), number of grain rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, grain weight cob^{-1} (g), 100 grain weight (g) and shelling (%) recorded highest with Broad Bed and Furrow Planting method and weed free plots. Significantly highest grain (60.99 q ha^{-1}) and stover yield (116.14 q ha^{-1}) was recorded in broad bed and furrow method of planting as compared to other land configuration methods of planting. Among weed management practices, weed free plot produce significantly maximum grain (65.53 q ha^{-1}) and stover yield (121.46 q ha^{-1}) as compared to all other treatments.

Keywords: Land configuration, weed management, kharif hybrid maize, atrazine, halosulfuron methyl

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crop in the world. It belong to family Poaceae, broadly used in industries besides serving as human food and animal feed. Maize is called 'queen of cereal' because it has highest genetic yield potentiality and wide adaptability under various agro climatic condition than any other cereal crops (Singh, 2013). Globally, maize is grown on more than 175 m ha across 165 countries with a production of around 1068.30 m tonnes. India stands 5th rank in acreage and 8th rank in production of maize (Anonymous, 2020a) [1]. In India, maize is the third most important food grain crop after wheat and rice. It is cultivated on 9.72 million hectares area with a production of 28.64 million tonnes having productivity of 2945 kg ha^{-1} and contributes about 3% towards total world production (Anonymous, 2020b) [2].

Land configuration plays a major role in minimizing soil erosion and improving water use efficiency and also increases availability of nutrients to crops (Chiroma *et al.*, 2008) [4]. Easy and uniform germination as well as growth and development of plant enhanced by manipulation of sowing methods. The superiority of ridges and furrow system could be ascribed to proper drainage of excess water coupled with adequate aeration at the time of irrigation or heavy rainfall. Ridges and furrow method of sowing improved grain as well as stover yield of maize over the flat bed method of sowing (Parihar *et al.*, 2010) [14].

Maize production suffers greatly due to weed problem, which offers multifarious limitations to the crop. It was found that due to continuous and heavy rains during entire vegetative and early reproductive stages of maize growth, weeds infestation becomes unmanageable throughout the

the growing period using the traditional method of interculturing and manual weeding. Though these methods are effective in controlling weeds during normal to low rainfall areas, they are tedious and time consuming besides labour intensive and costly. The choice of any weed control measures therefore, depends largely on its effectiveness and economics. Because of increased cost and non – availability of manual labour in required quantity for hand weeding, herbicides not only control the weeds timely and effectively but also offer a great scope for minimizing the cost of weed management irrespective of situation. Use of pre and post-emergence herbicides would make the herbicidal weed control more acceptable to farmers, which will not change the existing agronomic practices but will also allow for complete control of weeds.

2. Materials and Methods

The experiment was conducted during the mansoon season (*kharif*) 2018-19 and 2019-20 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, which is situated in the alluvial tract of Indo - Gangetic plains in central plain zone of Uttar Pradesh between 25° 26' to 26° 58' North latitude and 79° 31' to 80° 34'East longitude at an elevation of 125.9 meters from the sea level. This zone has semi-arid climatic conditions having alluvial fertile soil. The normal rainfall of the area is about 864.5 mm per annum (1971 – 2020) with average maximum temperature 33.09 °C and minimum temperature 24.54 °C. Most of the rains are received during June to September.

The soil type and fertility status were determined by the mechanical and chemical analysis of the soil. In order to ascertain physico-chemical properties of the experimental soil, primary soil samples were drawn randomly up to 15cm depth from different spots of the entire experimental area. The soil of the experimental field was sandy loam in texture, well drained, plane topography, slightly saline in nature having initial values of pH (7.80), EC (0.34 dsm^{-1}), low in organic carbon (0.32%), low in available nitrogen (170.60 kg ha^{-1}), medium in phosphorus (14.10 kg ha^{-1}) and Potash (154.00 kg ha^{-1}).

The field experiment was laid out in Split Plot Design. There were eighteen treatment combinations consisting of three land configuration methods as a main treatment *viz*; P_1-flat-bed planting, P_2-Ridge and furrow planting and P_3-Broad bed and furrow planting and six weed management practices were applied as sub treatment *viz*; W_1 -Pendimethalin @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post- emergence, W_2 -Atrazine @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post – emergence, W_3-Pendimethalin @ 1.0 kg ha^{-1} as pre- emergence + Halosulfuron methyl @ 67.5g. ha^{-1} at 15-20 DAS as post – emergence + one hand weeding at 45 DAS, W_4-Atrazine @ 1.0 kg ha^{-1} as pre – emergence + Halosulfuron methyl @ 67.5g ha^{-1} at 15-20 DAS as post – emergence + one hand weeding at 45 DAS, W_5- Weed free and W_6 -Weedy check. The treatments were replicated three times. The variety DKC –7074 of maize was sown row to row spacing of 60 cm and plant to plant spacing of 20 cm sown during second week of July with the seed rate of 20 kg/ha during both the years (2018 and 2019).

The observations were recorded on grain yield, stover yield, biological yield and harvest index as well as yield attributes such as number of cobs $plant^{-1}$, cob length (cm.), cob weight (g.), cob girth (cm.), number of grain rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, grain weight cob^{-1} (g), 100 grain weight (g) and shelling (%). For determining the yield attributes five plants from each plot were randomly selected and tagged. The number of cobs per plant was recorded on randomly selected five plants $plot^{-1}$ and sum was averaged out to obtain the number of cobs per plant. Cob length of five randomly selected cobs from selected plants was measured and then averaged to get length of one cob in centimeters. The cob girth of five randomly selected cob was measured with vernier calipers in the middle of the cobs, where the girth was found maximum and the mean was expressed in centimeters. Five randomly selected cobs from each net plot will be weighed and divided with five to compute individual cob weight (g). Such recording will be done separately for each net plot. The grains rows of five selected cobs were counted and the average was done to obtained number of grains rows per cob. Five cobs from the sampled plants were collected and grains per row were separated through shelling by manual labour. All grains per row were counted and then average was done to record number of grains per row. The number of grains counted on five sample cobs weighed separately for each treatment plot. The average grain weight per cob was recorded in grams. A sample of about 50g was drawn from each net plot and 100-grains were counted from each sample. These counted grains were weighed on physical balance and 100- grains weight was recorded in grams. Weight of grains will be taken from five randomly selected and sun-dried cobs from each net plot will be divided by respective cob weight to work out shelling per cent as follows:

$$\text{Shelling (\%)} = \frac{\text{five cob's grains weight (g)}}{\text{five cob's weight (g)}} \text{x } 100.$$

The yield parameters such as grain yield was recorded after threshing and winnowing, weight of grain produce of each plot was done on pan balance and figures obtained were recorded as grain yield in kg per plot, biological yield is also recorded after harvest, produce of each plot was weighed on spring balance and figures obtained were recorded in kilograms per plot. Later on these figures were converted into q ha^{-1} on the basis of plot area. While stover yield was worked out by differential method. Cob yield of each plot was subtracted from biological yield of respective treatment plot. Figures so obtained were taken as stover yield in kg per plot. Later it was converted into q ha^{-1} by multiplying with conversion factor on the basis of plot area. Harvest index is defined as the ratio of economic yield to total biological yield (Donald, 1962) and expressed in percentage. The harvest index for maize was worked out as indicated below.

$$\text{Harvest Index} = \frac{Economic\ yield\ (kg\ ha^{-1})}{Biological\ yield\ (kg\ ha^{-1})} \times 100.$$

The data collected from the experiments were subjected to statistical analysis by applying the procedure for Split Plot Design. Overall differences were tested by 'F' test at 5% level of significance as suggested by (Gomez and Gomez, 1984). In case of significant result, critical difference at 5% level of probability was also calculated for testing the significance between two treatment means.

Results

Yield Attributes The data related to effect of herbicidal application on yield and yield attributes are presented in Table 1 (Pooled data).

Table 1: Effect of land configuration and weed management practices on yield and yield attributes of kharif hybrid maize (pooled data of 2 year)

Treatment	No. of cobs plant^{-1}	Length of cob (cm.)	Weight of cob (g)	Girth of cob (cm.)	No. of grains cob^{-1}	No. of grain rows cob^{-1}	No. of grains rows^{-1}	Grain weight cob^{-1} (g)	Shelling (%)	100 Grains weight (g)	Grain yield (q ha^{-1})	Stover Yield (q ha^{-1})
Land configuration												
Flat-bed planting	1.19	18.00	157.70	11.23	406.05	12.84	31.34	112.44	71.17	25.93	58.35	113.16
Ridge and Furrow Planting	1.21	18.45	169.22	11.51	418.33	13.16	33.08	122.27	72.06	26.21	59.70	115.34
Broad Bed and Furrow Planting	1.25	18.80	180.32	11.77	443.90	13.48	33.85	132.00	73.06	26.34	60.99	116.14
S.Em±	0.01	0.11	3.69	0.04	3.37	0.14	0.28	3.01	0.31	0.17	0.39	0.38
C.D (P=0.05)	0.04	0.35	12.04	0.12	10.99	0.46	0.90	9.83	1.02	NS	1.28	1.24
Weed management												
Pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + Halosulfuron-methyl @ 67.5g ha^{-1} at 15-20 DAS as post emergence	1.14	17.28	156.50	10.76	371.72	12.35	30.82	110.61	70.63	25.72	62.61	117.45
Atrazine @ 1.0 kg ha^{-1} as pre-emergence + Halosulfuron-methyl @ 67.5g ha^{-1} at 15-20 DAS as post emergence	1.19	18.04	166.00	11.29	405.90	12.90	32.13	118.98	71.63	25.78	62.79	118.62
Pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + Halosulfuron-methyl @ 67.5g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS	1.23	18.86	174.60	11.70	435.98	13.37	33.27	127.59	73.04	26.39	63.51	119.74
Atrazine@ 1.0 kg ha^{-1} as pre-emergence + Halosulfuron-methyl @ 67.5g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS	1.26	19.23	179.75	12.03	462.48	13.78	34.22	133.57	74.27	27.16	64.38	120.59
Weed free	1.35	20.31	189.20	12.73	502.10	14.51	36.02	141.52	74.77	27.33	65.53	121.46
Weedy check	1.13	16.91	148.43	10.50	358.37	12.04	30.07	101.17	68.22	24.58	39.25	91.15
S.Em±	0.01	0.13	3.55	0.07	4.15	0.20	0.40	2.91	0.45	0.20	0.49	0.86
C.D (P=0.05)	0.04	0.38	10.04	0.20	11.73	0.58	1.12	8.24	1.29	0.58	1.38	2.44

Length of cob

Maximum cob length (18.80 cm) was recorded in Broad Bed and Furrow Planting and minimum (18.0 cm) in Flat-bed planting. Among herbicide treatments, maximum cob length (19.23 cm) was recorded with Atrazine @ 1.0 kg ha^{-1} as pre-emergence + Halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS both were statistically at par but significantly superior over all other treatments during both the years as well as pooled basis. However, the maximum cob length (20.31 cm.) recorded in weed free plot which was significantly superior over all other herbicidal treatments. The minimum cob length recorded in weedy check plot during both the years as well as pooled basis (16.90 cm.).

Number of cobs plant^{-1}

The number of cobs plant^{-1} observed maximum (1.25) in broad bed and furrow planting method of planting, while flat-bed method of planting was recorded minimum (1.19) number of cob plant^{-1}. Among herbicide treatments maximum number of cobs plant^{-1} (1.26) recorded with the herbicidal treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W_4) followed by pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W_3) both were statistically at par but significantly superior over all other treatments. However, the maximum number of cob plant^{-1} (1.35) recorded in weed free plot which was significantly superior over all other herbicidal treatments. The minimum number of cobs plant^{-1} recorded in weedy check on pooled basis (1.13).

Cob weight

The maximum cob weight (180.32 g) recorded with the broad bed and furrow method of planting followed by ridge and furrow method of Planting both were statistically at par but significantly superior over the flat-bed method of planting. Among herbicidal treatment the maximum cob weight (179.75g) recorded with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS both were statistically at par but significantly superior over all other treatments. However, the maximum cob weight (189.20 g) recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20

DAS as post emergence + one hand weeding at 45 DAS were applied. The minimum cob weight recorded in weedy check plot on pooled basis (148.43 g).

Cob girth

The pooled data related to cob girth as influenced by land configuration and weed management practices are presented in Table: 3. The maximum cob girth (11.77) recorded with the broad bed and furrow method of planting, followed by ridge and furrow method of planting, both were statistically at par but significantly superior over the flat-bed method of planting. Among the herbicidal treatment recorded maximum cob girth (12.03) with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by treatments where pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (11.70) both were statistically at par but significantly superior all other treatments during both the years as well as pooled basis. However, the maximum cob girth (12.73) recorded in weed free plot which was significantly superior over all other herbicidal treatments and minimum with the weedy check plots on pooled basis (10.50).

Number of grains Cob^{-1}

Perusal of data in Table 3 revealed that maximum number of grains cob^{-1} (443.90) were recorded under the broad bed and furrow method of planting, followed by ridge and furrow method of planting, both were statistically at par but significantly superior over the flat-bed method of Planting. Among herbicidal treatment the maximum number of grains cob^{-1} (462.48) recorded with atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by treatments where pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS both were statistically at par but significantly superior over all other treatments during both the years as well as pooled basis. However, the maximum number of grains cob^{-1} (502.10) recorded in weed free plot which was significantly superior over all other herbicidal treatments. The minimum number of grains cob^{-1} (358.37) recorded in weedy check plot.

Number of grain rows cob^{-1}

Number of grain rows cob^{-1} was non-significantly influenced by various land configurations and weed management practices (Table 3) but numerically broad bed and farrow method of planting (P_3) were observed maximum number of grain rows cob^{-1} (13.48), while flat-bed method of planting (P_1) were recorded minimum number of grain rows cob^{-1} on pooled basis. Among the herbicidal treatments maximum number of grain rows cob^{-1} (13.78) recorded with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by treatments where pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were done both were statistically at par but significantly superior over all other treatments during both the years as well as pooled basis. However, the maximum number of grain rows cob^{-1} (14.51) recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha-

^{1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied. The minimum number of grain rows cob^{-1} recorded in weedy check plot (12.04) on pooled basis.

Number of grains row^{-1}

The maximum number of grains row^{-1} (33.85) recorded with the broad bed and furrow method of Planting, followed by ridge and furrow method of Planting both were statistically at par but significantly superior over the flat-bed method of Planting. Among the herbicidal treatment maximum number of grains row^{-1} (34.22) recorded with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied followed by the treatment where pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W_3) were applied both were statistically at par but significantly superior over all other treatments during both the years as well as pooled basis. However, the maximum number of grains row^{-1} (34.22) recorded in weed free plot which was significantly superior over all other herbicidal treatments and minimum number of grains row^{-1} recorded in weedy check plot on pooled basis (30.07).

Grain weight cob^{-1}

Perusal of pooled data pertaining to grain weight cob^{-1} (Table 1) revealed that maximum grain weight per cob (132.00 g) was recorded with the broad bed and furrow method of planting followed by ridge and furrow method of planting, both were statistically at par but significantly superior over the flat-bed method of Planting. The maximum grain weight cob^{-1} (133.57 g) recorded with the herbicidal treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied followed by the treatment where pendimethaline @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied both were statistically at par but significantly superior over all other treatments during both the years as well as pooled basis. However, the maximum grain weight cob^{-1} (141.52 g) recorded in weed free plot which was significantly superior over all other treatments. The minimum grain weight cob^{-1} recorded in weedy check plot during both the years as well as pooled basis.

100 Grain weight

The results demonstrated that the land configuration have non-significant influence on 100 grains weight. Broad bed and farrow method of planting were observed maximum (26.34 g), while flat-bed method of planting was recorded minimum 100 grains weight. Among herbicide treatments 100 grains weight recorded significant result. The herbicidal treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W_4) recorded maximum 100 grain weight followed by treatments pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied both were statistically at par but significantly superior over all other treatments. However, the maximum 100 grains weight (27.33 g) recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied. The minimum recorded with the weedy check plot on pooled basis (24.585 g)

Shelling (%)

Pooled data presented in Table 3 indicated that the maximum shelling percentage (73.06%) recorded with the broad bed and furrow method of planting followed by ridge and furrow method of planting both were statistically at par but significantly superior over the flat-bed method of Planting. The herbicidal treatment where atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied recorded maximum shelling percentage (74.27%) followed by treatment where pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS both were statistically at par but significantly superior over all other treatments. However, the maximum shelling percentage (74.77%) recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied. The minimum shelling percentage recorded in weedy check plot on pooled baises (68.22%).

Grain and stover yield

The maximum grain yield (60.99 q ha^{-1}) and stover yield (116.14 q ha^{-1}) recorded with the broad bed and furrow method of planting, followed by ridge and furrow method of planting, both were statistically at par but significantly superior over the flat-bed method of planting. Among the herbicidal treatment maximum grain yield (64.38 q ha^{-1}) and stover yield (120.59 q ha^{-1}) recorded with the treatments where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied followed by treatments where pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied both were statistically at par but significantly superior over all other treatments. However, the maximum grain yield (65.53 q ha^{-1}) and stover yield (121.46 q ha^{-1}) recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W_4) were applied. The minimum grain and stover yield recorded in weedy check plot during both the years as well as pooled basis.

Discussion

Broad bed and furrow method of planting recorded significantly the highest yield attributes *viz*., cob length, cob weight, cob girth, number of grains cob^{-1}, number of grains row^{-1}, grain weight cob^{-1}, shelling (%) than flat-bed method of planting and it was at par with ridge and furrow method of planting. These results indicated that increase in yield attributing characters resulted into more vigorous crop growth due to favorable growing environment. The development of growth attributes is a function of dry matter accumulation by crop and its translocation for the formation of yield attributing characters of crop. While number of cobs plant^{-1}, number of grain rows cob^{-1}, 100 grain weight (g) was not influenced significantly but numerically maximum value of number of cobs plant^{-1}, number of grain rows cob^{-1}, 100 grain weight (g) was recorded under broad bed and furrow method of planting over flat-bed method of planting. Similar, results reported by NICRA, (2014) [13], Manwar and Mankar (2015) [10], Halli and Angadi (2017) [7] and Kori *et al.*, (2017) [9].

Among the herbicidal treatment the maximum number of cob plant^{-1}, cob length (cm.), cob weight (g.), cob girth (cm.), number of grains row cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, grain weight cob^{-1} (g), 100 grain weight (g) and shelling (%) recorded with the application of atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W4). Highest yield attributes under these treatments may be due to lesser crop-weed competition, which gave better environment for crop growth and development. Because in these treatments weed population and their growth was abstracted due to broad spectrum activity of mentioned herbicides and subsequent hand weeding. It confirms the conclusion drawn by Umesha *et al*., (2015) [15] and Yadav *et al*., (2017) [16].

Grain and stover yield are an ultimate result of growth and yield components. Land configuration showed significant influence on yield of crop. Broad bed and furrow method of planting recorded the highest grain, stover, biological yield and harvest index than other land configuration methods. This was attributed to higher yield attributing characters than ridge and furrow method of planting and flat-bed method of planting, respectively. These results further indicated that increased in yield contributing characters and yields in broad bed and furrow method of planting was due to better growing environment than other land configuration methods. These results are corroborated by the findings of Chavan (2011) [3], Halli and Angadi (2017) [7] and Joshi *et al.*, (2018) [8].

Significantly the highest grain, stover, biological yield as well as harvest index can be attributed due to marked improvement in yield attributes under the herbicidal treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS followed by pendimethaline @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS (W3) both were statistically at par but significantly superior all other treatments. However the maximum grain, stover, biological yield as well as harvest index recorded in weed free plot which was significantly at par with the treatment where atrazine @ 1.0 kg ha^{-1} as pre- emergence + halosulfuron-methyl @ 67.5 g ha^{-1} at 15-20 DAS as post emergence + one hand weeding at 45 DAS were applied due to relative weed free situation under herbicidal treatments reduced the crop weed competition and thus lead to higher vegetative growth and yield attributes significantly affected the grain and straw yield of maize. The minimum grain, stover, biological yield as well as harvest index recorded in weedy check plot because of more weed growth and poor performance of yield attributing characters, during both the years. These results are corroborated with the research results of Nazreen *et al.*, (2018) [12] and Mitra *et al*., (2018) [11].

Conclusion

On the basis of present investigation, it may conclude that herbicidal application of atrazine @ 1.0 kg ha^{-1} as pre-emergence + halosulfuron-methyl @ 67.5 g ha-1 at 15-20 DAS as post emergence + one hand weeding at 45 DAS of *kharif* hybrid maize planted with broad bed and furrow method of land configuration are found to be most favorable for better yield of maize.

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