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# Optimization of Agro-Techniques to Maximize Productivity and Economics Profits of Maize (*Zea mays* L.) Under Irrigated and Non-Irrigated Conditions

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## ABSTRACT

*Two field experiments were conducted at Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2012 and 2013 under irrigated and un-irrigated mulched conditions with the objective to study the growth and yield of maize at different planting dates and planting density and to simulate trends of maize production. Experiment was laid in split-plot design assigning four planting dates 15th April ($D_1$), 30th April ($D_2$), 15th May ($D_3$) and 30th May ($D_4$) to main plots and three planting density 50cm×20cm ($S_1$), 60cm×20cm ($S_2$) and 70cm×20cm ($S_3$) to sub-plots. The planting date 15th April ($D_1$) produced highest yield of 50.60 and 53.81 q ha$^{-1}$ under irrigated conditions and 43.59 and 45.28 q ha$^{-1}$ under un-irrigated mulched conditions during 2012 and 2013, respectively. Among planting density 60cm×20cm ($S_2$) recorded highest grain yield of 42.32 and 44.72 q ha$^{-1}$ under irrigated conditions and 36.63 and 38.53 q ha$^{-1}$ under un-irrigated mulched conditions during 2012 and 2013, respectively. Under irrigated conditions highest net return (US$. 87170), gross return (US$. 1810), and B: C ratio (2.18) was observed with treatment combinations of 15th April ($D_I$) with 60cm×20cm ($S_2$). The next best treatment combination was 15th April ($D_I$) with 50cm×20cm ($S_1$) with net return (US$. 1239), gross return (US$. 1804) and B: C ratio was 2.17. Un-irrigated mulched condition influenced the cost of production, gross return, net return and B: C ratio of crop. Highest net return (US$. 852), gross return (US$. 1586), and B: C ratio (1.16) was observed with treatment combinations of 15th April ($D_1$) with 60cm×20cm ($S_2$).*

***Key words:*** *Temperate Kashmir, US$, Planting dates, Planting density, Yield, Economics, B:C ratio.*

## INTRODUCTION

Maize known as the "Queen of Cereals" is the third most important cereal crop in India after rice and wheat and is cultivated on 8.17 million ha with the production of 19.73 million tonnes and productivity of 4.21 tonnes ha$^{-1}$ [1]. Among the major crops of Jammu and Kashmir in terms of acreage maize is grown in area of 315.81 thousand hectares with the production of 0.63 million tonnes and productivity of 2.0 tonnes ha$^{-1}$ [2].

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This increase in yield has been mainly achieved by increase in the area under high yielding varieties. However, the genetic potential of the improved varieties is at least three times of the present average yield of the state. In India maize production in Jammu & Kashmir is 0.53 million tones on an area of 3.17 million hectares with an average yield of 1776 Kg $ha^{-1}$ [3].

Maize is grown under wide range of climatic conditions, mostly in warmer parts of the temperate region and areas of humid sub-tropical climate. It is grown practically at all altitudes except where it is too cold or the growing season is too short. The crop requires considerable moisture and warmth from the time of planting to the termination of flowering period. The amount and distribution of rainfall are important in maize production. Maize cannot tolerate water stagnation. Rainfall of 50-75 cm during the vegetative period is helpful for proper development of maize plant. Moisture stress at the flowering stage drastically lowers the grain yield. Maize is grown in the state during *kharif* season and about 85% of the cropped area is rainfed. Under such considerable rainfed area and there is scope of increasing productivity by using low cost available mulch as under existing agro- climatic condition, the maize crop, is prone to the vagaries of rainfall distribution during crop growth. Application of full water requirement of plants is not economical. It is advisable to irrigate with 75% water requirement. This gives similar yield while saving a lot on water and labour. However, the 66,000 plants per hectare treatment should be used as it translates to higher yield and more protection for the soil[4]. The productivity potential of hybrid/composite cannot be realized without proper management practices. The optimum date of sowing is important for maize so that the genotype grown can complete its life cycle under optimum environmental conditions. Rainfed agriculture covers 80% of the world's cultivated land, and contributes about 60% to the total crop production[5]. There are various options for increasing 'crop yield per drop and bag', such as straw mulching and plastic mulching. These soil mulching management techniques can reduce evaporation and erosion, modify soil temperature, and reduce weed infestation, and thereby may lead to increases in yield, and possibly water use efficiency (WUE) and nitrogen (N) use efficiency (NUE)[6].

Optimum plant density provides conditions for maximum light interception right from early period of crop growth. Sowing dates have a pronounced effect on the yield of maize. Maize is generally sown from mid week of April to last week of May in lower belts of Kashmir valley. However, the field may not be vacant at this appropriate time due to delay in harvesting of some rabi crops. A field experiment was therefore conducted to see the impact of date of sowing and planting density on productivity and economics of Maize under irrigated and unirrigated conditions.

## MATERIALS AND METHODS

The investigation was conducted at the experimental farm of Division of Agronomy at main Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar which is situated 16 Km away from city center that lies between 34.08 $^{o}$ N latitude and 74.83 $^{o}$ E longitude at an altitude of 1587 meters above the mean sea level. The climate is temperate type characterized by hot summers and severe winters. The average annual precipitation over past twenty-five years is 786 mm (Division of Agronomy, SKUAST-Kashmir) and more than 80 % of precipitation is received from western disturbances during winter/spring months. During crop growth period (15$^{th}$ April - 4$^{th}$ October) the maximum temperature ranged between 18$^{0}$C to 32$^{0}$C, while minimum temperature ranged between 4.30 $^{0}$C to 17.78 $^{0}$C with relative humidity 49-89% (maximum) and minimum being between 23% to 86%. The mean monthly meteorological data collected for the cropping season of 2012 and 2013 during experimental period recorded at the Meteorological observatory at Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar.

The experiment included four dates of sowing with three levels of spacing was laid out in a Split Plot Design with three replications assigning four planting dates 15th April ($D_1$), 30th April ($D_2$), 15th May ($D_3$) and 30th May ($D_4$) to main plots and three planting density 50cm×20cm ($S_1$), 60cm×20cm ($S_2$) and 70cm×20cm ($S_3$) to sub-plots. Certified seed of maize variety "$C_6$" was used in the experiment. It matures in 155 to 160 days in the valley and 125 to 130 days in the mid elevations. Urea, Diammonium phosphate (DAP), Muriate of potash (MOP) and zinc sulphate were used as source of nitrogen, phosphorus, potassium, and zinc respectively. A fertilizer dose of 10 ton FYM $ha^{-1}$, 120 kg N $ha^{-1}$, 60 kg $P_2O_5$ $ha^{-1}$, 30 kg $K_2O$ $ha^{-1}$, 20 kg $ZnSO_4$ $ha^{-1}$ was applied. A fertilizer dose of 10 ton FYM $ha^{-1}$, 90 kg N $ha^{-1}$, 60 kg $P_2O_5$ $ha^{-1}$, 30 kg $K_2O$ $ha^{-1}$, 10 kg $ZnSO_4$ $ha^{-1}$ was applied. Half of recommended nitrogen was applied as basal dose and rest of nitrogen in two splits. Ist split at knee high stage and 2nd at tasseling stage. Phosphorus, potassium and zinc sulphate was applied, as per the recommendation as basal dose at the time of sowing. Furrow method of irrigations was followed. Irrigation was applied at IW/CPE ratio 0.75 in Experiment-I. In IW: CPE approach, cumulative pan evaporation values from standard USWB class 'A' pan evaporimeter were used for scheduling of irrigation. A common depth of irrigation was maintained at 6 cm uniformly. Jenson *et al*[8]., and Valencia & Steven[9] reported mulching of the un-irrigated crop was done with the available rice straw. A thin layer of mulch of about 5-10cm was done. The grain yield of each net plot was thoroughly cleaned and sun dried. The yield from each plot was recorded separately as kg $plot^{-1}$ and then converted in q $ha^{-1}$. After removal of the cobs from stalks, the maize stover was sun dried and weighed to determine the stover yield in q $ha^{-1}$.

## RESULTS AND DISCUSSION

The planting dates and planting density influenced cost of production, gross return, net return and B: C ratio of maize crop. Under irrigated conditions highest net return (US$.1245), gross return (US$. 1810.57), and B: C ratio (2.18) was observed with treatment combinations of 15th April ($D_I$) with 60cm×20cm ($S_2$) Table 4. The next best treatment combination was 15th April ($D_I$) with 50cm×20cm ($S_1$) with net return (US$. 1239), gross return (US$. 126308) and B: C ratio was 2.17. Where lowest economics return was observed with treatment combination of 30th May ($D_4$) with 70cm×20cm ($S_3$). The corresponding value for net returns, gross return and B: C ratio was US$. 792, US$. 1353 and 1.39, respectively. 15th April ($D_1$) followed by 30th April ($D_2$). This is due to delay in sowing reduces the growth duration, LAI and dry matter production[9] The results are in conformity with the findings of Cantarero *et al*[10].

Under irrigated conditions highest net return (US$. 1245), gross return (US$. 1810), and B: C ratio (2.18) was observed with treatment combinations of 15th April ($D_I$) with 60cm×20cm ($S_2$). Lowest economic return was observed with treatment combination of 30th May ($D_4$) with 70cm×20cm ($S_3$). The corresponding value for net returns, gross return and B: C ratio was US$. 792, US$. 1353 and 1.39, respectively (Table 5). Highest net return (US$ 852), gross return (US$. 1586), and B: C ratio (1.16) was observed with treatment combinations of 15th April ($D_I$) with 60cm×20cm ($S_2$). Where lowest economics return was observed with treatment combination of 30th May ($D_4$) with 70cm×20cm ($S_3$). The corresponding value for net returns, gross return and B: C ratio was US$. 400, US$. 1138 and 0.54, respectively.

Data indicated that planting date and planting density of maize under un-irrigated mulched condition influenced the cost of production, gross return, net return and B: C ratio of crop Table 5. Highest net return (US$. 852), gross return(US$ 1586), and B:C ratio (1.16) was observed with treatment combinations of 15th April ($D_1$) with 60cm×20cm ($S_2$).The next best treatment combination was 15th April ($D_1$) with 50cm×20cm ($S_1$) net return (US$ 816), gross return (US$ 1550) and B:C ratio was 1.11. Where lowest economics return was observed with treatment combination of 30$^{th}$ May ($D_4$) with 70cm×20cm ($S_3$). The corresponding value for net returns, gross return and B: C ratio was US$ 400,US$ 1138 and 0.54, respectively. Among planting density 60cm×20cm ($S_2$) significantly recorded higher yield attributing characters like cob length, number of grains row$^{-1}$, number of rows cob$^{-1}$, and cob diameter during both the years. Spacing 70cm×20cm ($S_3$) significantly exhibited more number of grains cob$^{-1}$ while other yield attributing characters were least. However minimum yield attributing characters were recorded in spacing 50cm×20cm ($S_1$) during both the years (table 2). During 2013, significantly superior grain yield was obtained with 15$^{th}$ April ($D_1$) and was at par with 30$^{th}$ April ($D_2$) which in turn was at par with 15$^{th}$ May ($D_3$) as compared to other planting date. However, during 2012, 15$^{th}$ April ($D_1$), 30$^{th}$ April ($D_2$) and 15$^{th}$ May ($D_3$) were at par with each other and significantly higher over 30$^{th}$ May ($D_4$). Lowest grain yield was recorded in 30$^{th}$ May ($D_4$) in 2012. The magnitude of superiority by 15$^{th}$ April ($D_1$) sowing over 30$^{th}$ April ($D_2$), 15$^{th}$ May ($D_3$) and 30$^{th}$ May ($D_4$) sowing was 3.42, 8.72 & 54.24 % in 2012.The corresponding value during 2013 was 10.23, 19.68 & 52.51 %, respectively. The results are in the corroboration with the findings of Marchao *et al*[11]. Since spacing 60cm×20cm ($S_2$) recorded comparatively longer growth phases, better dry matter production and partitioning resulting better yield attributing characters (Table 1).

The present investigation revealed that planting date and planting density under un-irrigated mulched condition planting date 15$^{th}$ April ($D_1$) being at par with 30$^{th}$ April ($D_2$) sowing recorded significantly higher stover yield over other planting dates. In turn 30$^{th}$ April ($D_2$) sowing was at par with 15$^{th}$ May ($D_3$) in both the years but significantly superior over 30$^{th}$ May ($D_4$) planting dates. While, 30$^{th}$ May ($D_4$) recorded lower stover yield as compared to other planting dates during both the years. The magnitude of superiority by 15$^{th}$ April ($D_1$) over 30$^{th}$ April ($D_2$), 15$^{th}$ May ($D_3$) and 30$^{th}$ May ($D_4$) was 4.25, 11.09 and 20.90 % in 2012. Whereas the corresponding values during 2013 was 4.86, 11.28 and 22.22 %, respectively.

With regard to various spacing, planting dates at 15$^{th}$ April ($D_1$) being at par with 30$^{th}$ April ($D_2$), and 15$^{th}$ May ($D_3$) recorded significantly higher grain yield as compared to 30$^{th}$ May ($D_4$) sowing during both the years. However, lower grain yield was recorded in 30$^{th}$ May ($D_4$) during both the years. The magnitude of superiority by 15$^{th}$ April ($D_1$) over 30$^{th}$ April ($D_2$), 15$^{th}$ May ($D_3$) and 30$^{th}$ May ($D_4$) was 8.14, 15.76 and 55.24 % in 2012. Whereas the corresponding values during 2013 was 8.08, 15.32 and 5.51%, respectively. Stover yield of maize differed significantly due to planting dates and planting density. It is depicted from the Table 4. during 2013, planting date 15$^{th}$ April ($D_1$) being at par with 30$^{th}$ April ($D_2$) sowing significantly recorded higher stover yield than other sowing dates. Significantly lower stover yield was recorded with 30$^{th}$ May ($D_4$) sowing in both the years. The magnitude of superiority by 15$^{th}$ April ($D_1$) over 30$^{th}$ April ($D_2$), 15$^{th}$ May ($D_3$) and 30$^{th}$ May ($D_4$) was 6.82, 15.35 and 23.47 % in 2012. Corresponding values for the year 2013 was 5.48, 14.00 and 22.64 %.

Among plant densities, there was significant difference between spacing over stover yield during both the years. Spacing 50cm×20cm ($S_1$) significantly recorded higher stover yield over other treatments during both the years. Though difference between 50cm×20cm ($S_1$) and 60cm×20cm ($S_2$) was not significant. In turn spacing 60cm×20cm ($S_2$) was at par with 70cm×20cm ($S_3$) in both the years. Lower stover yield was recorded with plant density 70cm×20cm ($S_3$) in both the years than other treatments. The magnitude of superiority by spacing 60cm×20cm ($S_2$) over 50cm×20cm ($S_1$) and 70cm×20cm ($S_3$) was 2.86 and 5.07% in 2012.The corresponding values for the year 2013 was 3.92 and 7.67 %.

With respect to planting density, there was significant difference between treatments during both the years. Spacing 60cm×20cm

($S_2$) recorded significantly highest grain yield than 50cm×20cm ($S_1$) and 70cm×20cm ($S_3$) spacing during both the years. Where spacing 60cm×20cm ($S_2$) was at par with 70cm×20cm ($S_3$) during 2012. In turn 70cm×20cm ($S_3$) was at par with 50cm×20cm ($S_1$). Where difference between 50cm×20cm ($S_1$) and 70cm×20cm ($S_3$) was not significant in 2013. However, lowest grain yield was recorded in 50cm×20cm ($S_1$) in during both the years. The magnitude of superiority by spacings 60cm×20cm ($S_2$) over 50cm×20cm ($S_1$) and 70cm×20cm ($S_3$) was 8.54 and 5.10 % in 2012. The corresponding values for the year 2013was 8.66 and 8.07 %. data revealed that spacing 50cm×20cm ($S_1$) being at par with 60cm×20cm ($S_2$) recorded significantly highest stover yield than 70cm×20cm ($S_3$) spacing in both the years. Whereas lowest stover yield was recorded with 70cm×20cm ($S_3$). The magnitude of superiority by spacing 50cm×20cm ($S_1$) over 60cm×20cm ($S_2$) and 70cm×20cm ($S_3$) was 3.49 and 11.50 % in 2012. The corresponding values for the year 2013 were 3.81 and 11.86 %. influenced the cost of production, gross return, net return and B: C ratio of crop. Highest net return (US$ 852), gross return (US$ 1586), and B:C ratio (1.16) was observed with treatment combinations of 15th April ($D_I$) with 60cm×20cm ($S_2$) (table 7). The next best treatment combination was 15th April ($D_I$) with 50cm×20cm ($S_2$) net return (US$ 816), gross return (US$ 1550) and B: C ratio was 1.11. Whereas lowest economics return was observed with treatment combination of 30th May ($D_4$) with 70cm×20cm ($S_3$). The corresponding value for net returns, gross return and B: C ratio was US$ 400,US$ 1138 and 0.54, respectively.

**Table 1: Effect of planting dates and planting density on the yield attributes of maize under irrigated conditions**

| Treatments | Cob Length (cm) | | Grains row$^{-1}$ | | Rows cob$^{-1}$ | | Grains cob$^{-1}$ | | Cobs plant$^{-1}$ | | Cob diameter (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| **Planting dates** | | | | | | | | | | | | |
| 15th April (16th SMW - $D_1$) | 16.39 | 16.51 | 20.31 | 20.09 | 12.12 | 12.24 | 243.49 | 245.90 | 1.12 | 1.16 | 33.79 | 33.82 |
| 30th April (18th SMW -$D_2$) | 15.40 | 15.64 | 19.23 | 19.55 | 12.26 | 12.09 | 235.75 | 236.35 | 1.09 | 1.22 | 32.84 | 33.34 |
| 15th May (20th SMW - $D_3$) | 13.70 | 13.91 | 19.41 | 19.46 | 11.63 | 11.94 | 225.74 | 232.35 | 1.08 | 1.10 | 32.60 | 32.66 |
| 30th May (22nd SMW- $D_4$) | 10.06 | 10.31 | 15.64 | 16.34 | 10.36 | 10.73 | 162.03 | 175.32 | 0.96 | 0.98 | 27.55 | 28.29 |
| SEm± | 0.71 | 0.66 | 0.68 | 0.61 | 0.39 | 0.37 | 10.25 | 11.72 | 0.01 | 0.02 | 0.41 | 0.53 |
| CD ($p \leq 0.05$) | 2.11 | 2.06 | 2.13 | 1.91 | 1.22 | 1.18 | 35.48 | 37.14 | 0.06 | 0.07 | 1.85 | 1.85 |
| **Planting density** | | | | | | | | | | | | |
| 50cm × 20cm ( $S_1$) | 13.20 | 13.44 | 17.82 | 18.01 | 10.62 | 10.72 | 189.24 | 193.06 | 1.04 | 1.09 | 31.88 | 32.21 |
| 60cm × 20cm ( $S_2$) | 14.90 | 14.98 | 20.31 | 19.21 | 11.40 | 11.45 | 231.53 | 219.95 | 1.08 | 1.15 | 32.10 | 32.30 |
| 70cm × 20cm ( $S_3$) | 13.55 | 13.86 | 19.85 | 19.37 | 12.27 | 13.10 | 253.08 | 253.74 | 1.06 | 1.10 | 31.11 | 31.55 |
| SEm± | 0.19 | 0.17 | 0.40 | 0.36 | 0.23 | 0.25 | 7.63 | 7.94 | 0.004 | 0.006 | 0.10 | 0.07 |
| CD ($p \leq 0.05$) | 0.56 | 0.51 | 1.25 | 1.17 | 0.80 | 0.79 | 23.98 | 24.23 | 0.02 | 0.02 | 0.33 | 0.25 |

**Table 2: Grain yield, stover yield, biological yield , harvest index and seed index of maize as influenced by planting dates and planting density under irrigated conditions**

| Treatments | Grain Yield (q ha$^{-1}$) | | Stover yield (q ha$^{-1}$) | | Biological yield (q ha$^{-1}$) | | Harvest index (%) | | Seed index (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| **Planting dates** | | | | | | | | | | |
| 15th April (16th SMW - $D_1$) | 50.60 | 53.81 | 71.05 | 71.27 | 121.65 | 125.08 | 41.59 | 43.20 | 22.02 | 22.33 |
| 30th April (18th SMW -$D_2$) | 47.18 | 48.30 | 66.20 | 67.36 | 113.38 | 115.66 | 41.61 | 41.76 | 21.40 | 21.88 |
| 15th May (20th SMW - $D_3$) | 41.88 | 43.22 | 60.14 | 61.29 | 102.02 | 104.51 | 41.05 | 41.35 | 20.40 | 20.01 |
| 30th May (22nd SMW- $D_4$) | 23.15 | 25.55 | 54.37 | 55.13 | 77.52 | 80.68 | 29.86 | 31.66 | 17.32 | 17.59 |
| SEm± | 3.18 | 3.20 | 1.81 | 1.72 | 4.19 | 4.92 | 1.26 | 1.22 | 0.50 | 0.51 |
| CD ($p \leq 0.05$) | 9.15 | 9.42 | 5.56 | 5.38 | 12.32 | 14.23 | 3.91 | 3.84 | 1.56 | 1.58 |
| **Planting density** | | | | | | | | | | |
| 50cm × 20cm ( $S_1$) | 40.20 | 42.56 | 64.68 | 66.31 | 104.88 | 108.62 | 38.32 | 39.13 | 19.68 | 19.70 |
| 60cm × 20cm ( $S_2$) | 42.32 | 44.72 | 62.83 | 63.74 | 105.15 | 108.46 | 40.24 | 41.23 | 20.87 | 20.93 |
| 70cm × 20cm ( $S_3$) | 39.59 | 40.89 | 61.40 | 61.22 | 100.99 | 101.60 | 39.20 | 39.74 | 20.30 | 20.73 |
| SEm± | 0.81 | 0.69 | 0.85 | 0.92 | 0.48 | 0.75 | 0.22 | 0.24 | 0.12 | 0.13 |
| CD ($p \leq 0.05$) | 2.52 | 2.14 | 2.75 | 2.96 | 1.50 | 2.31 | 0.64 | 0.70 | 0.39 | 0.41 |

**Table 3: Effect of planting dates and planting density on the yield attributes of maize under un-irrigated mulched conditions**

| Treatments | Cob Length (cm) | | Grains row$^{-1}$ | | Rows cob$^{-1}$ | | Grains cob$^{-1}$ | | Cobs plant$^{-1}$ | | Cob diameter (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| **Planting dates** | | | | | | | | | | | | |
| 15$^{th}$April (16$^{th}$ SMW - $D_1$) | 15.72 | 15.95 | 19.82 | 19.92 | 12.14 | 12.21 | 240.61 | 243.10 | 1.03 | 1.05 | 33.96 | 34.25 |
| 30$^{th}$April (18$^{th}$ SMW -$D_2$) | 14.90 | 15.19 | 19.62 | 19.66 | 12.05 | 12.00 | 236.42 | 235.92 | 1.00 | 1.02 | 33.54 | 33.72 |
| 15$^{th}$ May (20$^{th}$ SMW - $D_3$) | 13.43 | 13.72 | 19.13 | 19.32 | 11.69 | 11.83 | 223.62 | 228.55 | 0.97 | 0.98 | 32.21 | 32.54 |
| 30$^{th}$ May (22$^{nd}$ SMW- $D_4$) | 10.00 | 10.21 | 15.93 | 15.55 | 10.55 | 10.34 | 168.06 | 160.78 | 0.85 | 0.87 | 27.39 | 27.58 |
| SEm $\pm$ | 0.58 | 0.62 | 0.55 | 0.62 | 0.19 | 0.27 | 9.56 | 10.02 | 0.02 | 0.02 | 0.48 | 0.41 |
| CD ($p \leq 0.05$) | 1.90 | 1.92 | 1.74 | 2.18 | 0.68 | 0.96 | 31.70 | 34.71 | 0.06 | 0.06 | 1.69 | 1.45 |
| **Planting density** | | | | | | | | | | | | |
| 50cm × 20cm ( $S_1$) | 13.21 | 13.37 | 17.79 | 17.89 | 10.79 | 10.68 | 191.95 | 191.06 | 0.94 | 0.96 | 31.61 | 31.95 |
| 60cm × 20cm ( $S_2$) | 14.09 | 14.41 | 19.06 | 19.11 | 11.16 | 11.29 | 215.75 | 217.66 | 0.97 | 0.99 | 32.14 | 32.43 |
| 70cm × 20cm ( $S_3$) | 13.25 | 13.52 | 19.01 | 18.83 | 12.87 | 12.81 | 244.65 | 241.21 | 0.96 | 0.98 | 31.57 | 31.69 |
| SEm $\pm$ | 0.08 | 0.10 | 0.23 | 0.31 | 0.20 | 0.29 | 8.16 | 8.64 | 0.003 | 0.003 | 0.05 | 0.06 |
| CD ($p \leq 0.05$) | 0.32 | 0.34 | 0.78 | 1.06 | 0.64 | 0.93 | 26.04 | 26.97 | 0.01 | 0.01 | 0.19 | 0.24 |

**Table 4: Grain yield, stover yield, biological yield, harvest index and seed index of maize as influenced by planting dates and planting density under un-irrigated mulched conditions**

| Treatments | Grain yield (q ha$^{-1}$) | | Stover yield (q ha$^{-1}$) | | Biological yield (q ha$^{-1}$) | | Harvest index (%) | | Seed index (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| **Planting dates** | | | | | | | | | | |
| 15$^{th}$April (16$^{th}$ SMW - $D_1$) | 43.59 | 45.28 | 61.55 | 63.27 | 105.14 | 108.55 | 41.45 | 41.71 | 21.04 | 21.11 |
| 30$^{th}$April (18$^{th}$ SMW -$D_2$) | 40.04 | 41.62 | 58.93 | 60.19 | 98.97 | 101.81 | 40.45 | 40.88 | 20.21 | 20.45 |
| 15$^{th}$ May (20$^{th}$ SMW - $D_3$) | 36.72 | 38.34 | 54.72 | 56.13 | 91.44 | 94.47 | 40.16 | 40.58 | 20.14 | 20.29 |
| 30$^{th}$ May (22$^{nd}$ SMW- $D_4$) | 19.51 | 20.28 | 48.68 | 49.21 | 68.19 | 69.49 | 28.61 | 29.18 | 16.17 | 16.73 |
| SEm $\pm$ | 2.57 | 2.69 | 1.36 | 1.49 | 4.31 | 4.45 | 1.38 | 1.31 | 0.50 | 0.46 |
| CD ($p \leq 0.05$) | 8.02 | 8.33 | 4.29 | 4.68 | 12.31 | 13.02 | 4.28 | 4.17 | 1.62 | 1.46 |
| **Planting density** | | | | | | | | | | |
| 50cm × 20cm ( $S_1$) | 33.50 | 35.19 | 58.92 | 60.36 | 92.42 | 95.55 | 36.24 | 37.19 | 18.03 | 18.64 |
| 60cm × 20cm ( $S_2$) | 36.63 | 38.53 | 56.86 | 58.06 | 93.49 | 96.59 | 39.18 | 40.75 | 20.17 | 20.49 |
| 70cm × 20cm ( $S_3$) | 34.76 | 35.42 | 52.14 | 53.20 | 86.90 | 88.62 | 40.00 | 39.96 | 19.97 | 19.81 |
| SEm $\pm$ | 0.84 | 0.85 | 0.78 | 0.81 | 0.65 | 0.77 | 0.62 | 0.61 | 0.22 | 0.23 |
| CD ($p \leq 0.05$) | 2.69 | 2.68 | 2.26 | 2.38 | 2.06 | 2.39 | 2.01 | 1.94 | 0.71 | 0.75 |

**Table 5: Relative economics of maize as influenced by different planting dates and planting density under irrigated conditions**

| Treatments | Cost of cultivation (US$ $ha^{-1}$) | Gross returns (US$. $ha^{-1}$) | Net return (US$. $ha^{-1}$) | Benefit : Cost ratio |
|---|---|---|---|---|
| **(15th April)× (50cm×20cm)** | 170 | 1804 | 1239 | 2.17 |
| **( 15th April)× (60cm×20cm)** | 170 | 1811 | 1245 | 2.18 |
| **(15th April)× (70cm×20cm)** | 170 | 1786 | 1220 | 2.14 |
| **(30th April)× (50cm×20cm)** | 170 | 1721 | 1156 | 2.03 |
| **(30th April)× (60cm×20cm)** | 170 | 1727 | 1162 | 2.04 |
| **(30th April)× (70cm×20cm)** | 170 | 1702 | 1137 | 1.99 |
| **(15th May)× (50cm×20cm)** | 170 | 1679 | 1114 | 1.95 |
| **(15th May)× (60cm×20cm)** | 170 | 1685 | 1120 | 1.96 |
| **(15th May)× (70cm×20cm)** | 170 | 1661 | 1095 | 1.92 |
| **(30th May)× (50cm×20cm)** | 170 | 1372 | 812 | 1.42 |
| **(30th May)× (60cm×20cm)** | 170 | 1378 | 818 | 1.43 |
| **(30th May)× (70cm×20cm)** | 170 | 1353 | 793 | 1.39 |

| | | |
|---|---|---|
| **Cost of seed = US$. 0.4 $kg^{-1}$,** | **Cost of fertilizer:US$.** | **Cost of tractorization = US$. 70 $ha^{-1}$** |
| **Cost of stover= US$..02 $kg^{-1}$** | **Urea= 0.08 $kg^{-1}$, DAP=0 .32 $kg^{-1}$, MOP= 0.24 $kg^{-1}$** | **Irrigation (8 Mandays @ US$ 2.14)** |

**Table 6: Cost of Cultivation for Maize Under Irrigated Conditions**

| S. No | | Operations/Inputs | No./Qty | Rate (US$) | Cost $ha^{-1}$ |
|---|---|---|---|---|---|
| **A** | | **Power cost** | | | |
| | 1 | Tractorization (Harrowing, Cultivator and Planking) | | | 100 |
| | | **Total** | | | 100 |
| **B** | | **Sowing Operations** | | | 0 |
| | 1 | Cost of seed | 25 kg $ha^{-1}$ | 0.4 kg | 10 |
| | 2 | Sowing (Sowing of seed and basal fertilizer placement, opening of furrows etc) | 45 Mandays | 2.4/day | 10 |
| | | **Total** | | | 20 |
| **C** | | **Fertilizer Management (120:60:30; NPK and $ZnSO_4$ :15-20kg $ha^{-1}$ )** | | | 0 |
| | 1 | Urea | 210 kg | 0.08 $kg^{-1}$ | 17 |
| | 2 | DAP | 130 kg | 0.32 $kg^{-1}$ | 42 |
| | 3 | MOP | 50 kg | 0.24 $kg^{-1}$ | 12 |
| | 4 | $ZnS0_4$ | 20 kg | | 0 |
| | 5 | Application (Basal + Split) | 5 Mandays | 2.4 | 11 |
| | | **Total** | | | 81 |
| **D** | | **Herbicide Application** | | | 0 |
| | 1 | Atrazine | 1 kg a.i $ha^{-1}$ | 4.29 $kg^{-1}$ with 50% a.i | 9 |
| | 2 | Atrazine application | 2 Mandays | 2.4/= | 4 |
| | | **Total** | | | 13 |
| **E** | | **Irrigation (4 times)** | 8 Mandays | 2.4 | 17 |
| **F** | | Hoeing, weeding and earthing up (At Knee high stage and 50-55 DAS) | 50 Mandays | 2.4 | 107 |
| | | **Total** | | | 107 |
| **G** | | Watch and Ward | 15 Mandays | 2.4 | 32 |
| | | **Total** | | | 32 |
| **H** | 1 | Cob picking and harvesting | 40 Mandays | 2.4 | 86 |
| | 2 | Drying | 3 Mandays | 2.4 | 6 |
| | 3 | Shelling and winnowing | 10 Mandays | 2.4 | 21 |
| | | **Total** | | | 114 |
| | | **Grand Total US$** | | | 570 |

**Table 7: Relative economics of maize as influenced by different Planting Dates and planting density under un-irrigated mulched conditions**

| Treatments | Cost of cultivation (US$ $ha^{-1}$) | Gross returns (US$$ha^{-1}$) | Net returns (US$ $ha^{-1}$) | Benefit : Cost ratio |
|---|---|---|---|---|
| **(15th April)× (50cm×20cm)** | 734 | 1550 | 816 | 1.11 |
| **(15th April)× (60cm×20cm)** | 734 | 1586 | 852 | 1.16 |
| **(15th April)× (70cm×20cm)** | 734 | 1536 | 802 | 1.09 |
| **(30th April)× (50cm×20cm)** | 734 | 1486 | 752 | 1.03 |
| **(30th April)× (60cm×20cm)** | 734 | 1522 | 788 | 1.07 |
| **(30th April)× (70cm×20cm)** | 734 | 1471 | 737 | 1.00 |
| **(15th May)× (50cm×20cm)** | 734 | 1463 | 729 | 0.99 |
| **(15th May)× (60cm×20cm)** | 734 | 1499 | 765 | 1.04 |
| **(15th May)× (70cm×20cm)** | 734 | 1448 | 715 | 0.97 |
| **(30th May)× (50cm×20cm)** | 734 | 1160 | 426 | 0.58 |
| **(30th May)× (60cm×20cm)** | 734 | 1196 | 462 | 0.62 |
| **(30th May)× (70cm×20cm)** | 734 | 1138 | 400 | 0.54 |

| | | |
|---|---|---|
| **Cost of seed = US$. 0.4 $kg^{-1}$,** | **Cost of fertilizer:US$.** | **Cost of tractorization = US$. 70 $ha^{-1}$** |
| **Cost of stover= US$..02 $kg^{-1}$** | **Urea= .08 $kg^{-1}$, DAP=0 .32 $kg^{-1}$, MOP= 0.24 $kg^{-1}$** | **Irrigation (8 Mandays @ US$ 2.14)** |

**Table 8. Cost of Cultivation for Maize under Un-Irrigated Conditions**

| S.No | | Operations/Inputs | No./Qty | Rate (US$) | Cost $ha^{-1}$ with tractorization |
|---|---|---|---|---|---|
| **A** | | **Power cost** | | | |
| | 1 | Tractorization (Harrowing, Cultivator and Planking) | | | 100 |
| | | **Total** | | | 100 |
| **B** | | **Sowing Operations** | | | 0 |
| | 1 | Cost of seed | 25 kg $ha^{-1}$ | 0.4 kg | 10 |
| | 2 | Sowing (Sowing of seed and basal fertilizer placement, opening of furrows etc) | 45 Mandays | 2.4/day | 10 |
| | | **Total** | | | 20 |
| **C** | | **Fertilizer Management** | | | 0 |
| | 1 | Urea | 160 kg | 0.08 $kg^{-1}$ | 17 |
| | 2 | DAP | 98 kg | 0.32 $kg^{-1}$ | 42 |
| | 3 | MOP | 33 kg | 0.24 $kg^{-1}$ | 12 |
| | 4 | $ZnS0_4$ | 10 kg | | 0 |
| | 5 | Application (Basal + Split) | 5 Mandays | 2.4 | 11 |
| | | **Total** | | | 81 |
| **D** | | **Herbicide Application** | | | |
| | 1 | Atrazine | 1 kg a.i $ha^{-1}$ | 4.29 $kg^{-1}$ with 50% a.i | 0 |
| | 2 | Atrazine application | 2 Mandays | 2.4/= | 9 |
| | | **Total** | | | 4 |
| E | | **Mulching** | 20 t $ha^{-1}$ | 2.4 | 13 |
| **F** | | Hoeing, weeding and earthing up (At Knee high stage and 50-55 DAS) | 50 Mandays | 2.4 | 17 |
| | | **Total** | | | 107 |
| **G** | | Watch and Ward | 15 Mandays | 2.4 | 107 |
| | | **Total** | | | 32 |
| **H** | 1 | Cob picking and harvesting | 40 Mandays | 2.4 | 32 |
| | 2 | Drying | 3 Mandays | 2.4 | 86 |
| | 3 | Shelling and winnowing | 10 Mandays | 2.4 | 21 |
| | | **Total** | | | 114 |
| | | **Grand Total US$** | | | 570 |

## CONCLUSION

In irrigated condition for higher grain yield planting density can be decreased i.e 40cm×20cm. Where under un-irrigated mulched condition planting density need to increased up to 65cm×20cm for higher grain yield, and under both (Irrigated & Unirrigated) conditions highest net return, gross return and B: C ratio was observed with treatment combinations of sowing on 15th April ($D_I$) with spacing 60cm×20cm ($S_2$). While lowest net return, gross return and B: C ratio was observed with treatment combination of 30th May ($D_4$) with spacing of 70cm×20cm ($S_3$). Since most of the maize area in Kashmir valley is rainfed. Therefore, mulching is strongly recommended.

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