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Influence of Irrigation Methods and Live Mulch on Productivity of Spring Maize (*Zea mays* L.)

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ABSTRACT

The field experiment was conducted to study the influence of irrigation methods and live mulching on productivity of spring maize (*Zea mays* L.) on sandy loam soil, low in organic carbon and available N and high in available P and K during the *spring* season of 2019. The experiment was laid out in split plot design with twelve treatment combinations having three irrigation methods viz; Conventional furrow irrigation (CFI), Alternate furrow irrigation (AFI) and Fixed furrow irrigation (FFI) in main plots and four live mulch treatments in sub plots including control, cowpea, moong and mash, and replicated four times. Growth attributes, yield components and grain yield were higher in CFI method than AFI and FFI methods. CFI and AFI methods gave higher maize grain yield (36.9 and 36.6 qha^{-1}, respectively) and straw yield (89.0 and 88.5 qha^{-1}, respectively) than the FFI method (33.3qha^{-1} grain yield and 85.3qha^{-1} straw yield). The various live mulches (intercropping) had also shown significant effects on growth and yield parameters. Cowpea mulching gave the maximum maize grain (38.6qha^{-1}) and straw (89.9qha^{-1}) yields followed by moong (37.9 and 89.4qha^{-1}) and mash (35.4 and 87.2qha^{-1}) live mulches.

***Key words*:** Alternate furrow irrigation, Deficit irrigation, Intercropping, Live mulching, Spring maize

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agroclimatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is also playing an important role in the crop diversification strategy of various states of India to look beyond paddy, which consumes huge amount of water, fertilizer and power. It is cultivated on nearly 150 mha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 percent in the global grain production. The United States of America (USA) the largest producer of maize contributes nearly 35 per cent of the total production in the world. In India, maize is third most important food crop after rice and wheat. Maize in India, contributes nearly 9 per cent in the national food basket and more than Rs. 100 billion to the agriculture GDP at current price.

Maize being a photo insensitive crop can be grown in all seasons viz. *Kharif* (monsoon), *post monsoon*, *Rabi* (winter) and *spring*. During *Rabi* and *spring* season to achieve higher yield at farmer's field assured irrigation facilities are required. *Spring* season maize grown in first week of February requires frequent irrigations during its active growth phase. At the same time in months of April and May evaporation demand of environment increases. To overcome this increased water evaporation demand, to increase the water use efficiency and to suppress the weed population some agronomic innovations like mulching, bed planting and different methods of furrow irrigation may be tried.

Irrigation is applied through furrows in three ways. Alternate furrow irrigation (AFI), fixed furrow irrigation (FFI) and conventional furrow irrigation (CFI). In alternate furrow irrigation less water is applied and furrows are irrigated alternatively and those un-irrigated furrow could obtain their water needs from the adjacent irrigated furrows through the horizontal movement of soil water. So, water application is reduced by 25 to 35 per cent in alternate furrow irrigation as compared to every furrow irrigation. Water has to be saved without much reduction in yield, but water use efficiency may increase [1]. Alternate furrow irrigation method may supply water in a manner that greatly reduces the amount of surface wetted, leading to less evapotranspiration and less deep percolation occur, more water alternately concentrated in a furrow may improve the conductivity of the soil-root system to water and fertilizers and more lateral roots are stimulated and a chemical signal is produced in drying roots to reduce the shoot water less. In all, irrigation water use can be decreased while maintaining the same yield level, and hence the WUE might be enhanced.

For conserving agricultural water, the fixed furrow irrigation is helpful. In this method the same furrows are fixed for irrigation, while adjacent furrows are not irrigated for the

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whole season. In general, these techniques are a trade off a lower yield for a higher water use efficiency, water was saved mainly by reduced evaporation, from the soil surface. Weed infestation may also be less in the furrows which are not irrigated. So, weed intensity is low in dry furrow than in irrigated furrows. These new practices of irrigations reduced the volume of water used and improved the water use efficiency. For successful establishment of spring maize, mulching may have beneficial effects. Mulching is a useful practice for controlling erosion, weed growth, surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil, and thus help to conserve significant amount of moisture. Live mulching through intercropped legume crop i.e., moong, mash and cowpea with maize has been found to be beneficial for erosion control, reduction of the weed infestation, enhanced moisture and nutrient conservation by fixing atmospheric nitrogen leading to increased productivity and soil heath. Mulch cover shields the soil from solar radiation thereby reducing evaporation from the soil. Soil biota increases under mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years [2]. For sustainable and organic agricultural production, the use of living mulch systems has increased in recent years, since these practices play a dual role in agroecosystem by protecting the soil from erosion and by enriching it with organic matter and nitrogen through rhizobium symbiosis. Living mulches are cover crops that are maintained as a living ground cover throughout the growing season of the main crop and it can be important for use as an ecologic

MATERIALS AND METHODS

A field experiment was conducted at Students' Research Farm, Department of Agriculture, Khalsa College, Amritsar during spring season 2019. The soil of the experimental site was sandy loam in texture having pH 7.6, low available nitrogen (154 kg/ha), low available phosphorus (28.9 kg/ha), high available potash (330 kg/ha). The experiment was carried out in split plot design, comprising 3 methods of irrigations (CFI, AFI and FFI) in main plot and 4 live mulch (cowpea, moong, mash and control) in sub plot and replicated four times. The irrigation methods were alternate furrow irrigation (AFI), fixed furrow irrigation (FFI) and conventional furrow irrigation (CFI). AFI means one of the two neighbouring furrows was alternately irrigated throughout the growing season. FFI means that irrigation was fixed to one of the two neighbouring furrows. CFI was the conventional way where all furrows were irrigated for every irrigation.

The field was ploughed and given pre-sowing irrigation. When the field reached at the optimum moisture conditions, it was ploughed four times with tractor drawn cultivator followed by planking each time. After the preparatory tillage, field was divided in four replications and each replication further divided into twelve different plots of same size. All treatment combinations were applied randomly in each replication. The pre-treated seeds of variety Dragon 1247 were sown by Kera method on 20th February 2019. On the same day live mulch crops such as cowpea, moong and mash were also sown in between the rows of spring maize as per treatment. All the treatments were watered on the same day. Five plants from plots were randomly selected and tagged for recording different observations regarding growth and yield parameters. The parameters like plant height, leaf area index, number of cobs per plant, cob length, number of grains per cob and dry weight of the plant were studied during the course of the study.

RESULTS AND DISCUSSION

Growth parameters

Growth parameters like plant height, leaf area index and dry matter were higher in conventional furrow irrigation method. Maximum plant height, leaf area index and dry matter were recorded with CFI method which was statistically at par with AFI method but significantly higher than the FFI method. So, CFI and AFI methods produced significantly better dry matter accumulation, plant height and leaf area index than the FFI method. The general trend observed under different irrigation methods was CFI > AFI > FFI. Maize plants grown under CFI method recorded deeper root system and larger deep percolation because more irrigated water was taken up by the plants and due to this reason, the plant height increased in CFI method [3].

Table 1 Influence of irrigation methods and live mulching on plant height (cm), leaf area index, dry matter accumulation (q/ha) of spring maize

Treatments	Plant height (cm)	Leaf area index	Dry matter accumulation (q/ha)
Irrigation methods			
CFI	177.8	3.60	125.1
AFI	174.4	3.10	122.0
FFI	163.9	2.59	114.4
CD (p = 0.05)	8.33	0.39	6.31
Live mulching			
Control	155.1	2.00	109.5
Mash	168.4	2.81	117.6
Moong	179.4	3.51	126.4
Cowpea	185.2	4.09	130.5
CD (p = 0.05)	11.9	0.73	7.65

All live mulch treatment had significant effect on growth parameters. All the three mulches such as cowpea, moong and mash mulching produced significantly higher LAI, plant height and dry matter over control (no mulch). All growth parameters were higher in Cowpea mulching which significantly differed from mash mulching, but it remained statistically at par with moong mulching. Further, it was observed that moong and mash mulching were at par with each other but superior over control plots. The probable reason that cowpea live mulch had more biomass which suppressed the weed and can reduced weed growth. Therefore, the competition for light, water and nutrient was less in cowpea mulching which helped in promoting the plant height, leaf area index and dry matter [4].

Yield attributes

The maximum number of grains per cob, cob length and test weight were recorded under CFI method which was statistically at par with AFI method. Both these methods i.e., CFI and AFI produced significantly higher yield attributes than FFI method. The minimum number of grains per cob, cob length and test weight was recorded in FFI method. This may be due to the small cob length and plant height observed in this irrigation method because of the reason that less water was applied in this method [5].

Table 2 Influence of irrigation methods and live mulching on cob length, numbers of grains per cob and test weight of spring maize

Treatments	Cob length (cm)	No. of grains per cob	Test weight (g)
Irrigation methods			
CFI	17.88	371.8	258.9
AFI	17.56	366.9	256.4
FFI	16.26	354.9	252.3
CD (p = 0.05)	1.25	10.40	3.26
Live mulching			
Control	15.48	336.0	249.8
Mash	16.82	362.0	254.6
Moong	17.99	376.2	258.8
Cowpea	18.50	384.3	259.9
CD (p = 0.05)	1.20	20.40	5.84

Different types of mulches have significant effect on yield attributes. Cowpea, moong and mash mulching produced significantly higher number of grains per cob, cob length and test weight over control (no mulch) plots. The maximum number of grains per cob, and test weight was obtained from the cowpea mulching which was significantly higher than the mash mulching but remained at par with moong mulching. It was further observed that moong mulching produced numerically higher number grains per cob, cob length and test weight than mash mulching but could not reach the level of statistical significance and remained at par with each other. Therefore, the plots having no mulch treatment were inferior and produced lowest yield attributes [6].

Grain yield and straw yield

The grain yield constitutes the most important component concerning the economic yield of crop. Grain yield is the end product and it is net result of various inputs, influencing growth and yield contributing characters. The data showed that the maize grain and straw yield was significantly affected by different irrigation methods. The highest grain yield of maize was obtained with conventional furrow irrigation (36.9 qha^{-1}) which was statistically higher than fixed furrow irrigation method (33.3q ha) but was at par with AFI method. The treatment AFI produced significantly better yield over FFI method. Lowest yield was observed in the fixed furrow irrigation method. The percent increase in grain yield was 10.8 and 9.9 in CFI and AFI method, respectively over FFI method. Increase in yield by CFI over FFI may be due to more water availability in CFI than FFI which is reflected from better growth parameter in terms of LAI, plant height, dry matter accumulation and yield parameter like number of cobs per plant, higher number of grains per cob and cob length etc. [7].

Effect of legume live mulch on maize grain yield was also significant. Maize grain and straw yield were significantly higher in plots where live mulch with cowpea, moong and mash was done over control (no mulch) plot. Among different types of mulching cowpea produced highest yield followed by moong and mash. Yield of maize in cowpea and moong mulched plots was at par with each other. Similarly maize yield in moong and mash mulched plots were also at par with each other. However, yield of maize in cowpea mulched plots were higher than the mash mulched plot. Higher grain yield of maize in cowpea mulched plots over other may be due to less weeds count and more biomass of live mulch crop which may be due to better efficiency of nitrogen fixation in cowpea than moong and mash mulching [8].

Table 3 Influence of irrigation methods and live mulching on grain yield, straw yield and harvest index of spring maize

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Irrigation methods			
CFI	36.9	89.0	29.3
AFI	36.6	88.5	29.2
FFI	33.3	85.3	28.2
CD (p = 0.05)	2.09	2.60	0.90
Live mulching			
Control	30.6	83.7	26.8
Mash	35.4	87.2	28.7
Moong	37.9	89.4	29.9
Cowpea	38.6	89.9	30.5
CD (p = 0.05)	2.93	2.30	1.50

Harvest index

Harvest index is the ability of crop plant to convert dry matter into economic or grain yield. Among the different irrigation methods CFI method had the highest harvest index value (29.3%) which was significantly different from the FFI (28.2%). The minimum harvest index value was observed in FFI method. While, value of harvest index in CFI and AFI treatments were at par with each other. However, numerically CFI produced higher harvest index than AFI method but the difference could not reach to the level of significance. The percent increase in harvest index was 3.4 and 3.5 with CFI and AFI method respectively, over FFI method. The reason behind the minimum harvest index in FFI method may be the deficient water conditions which limits the proper growth of plants, so that this method decreased the harvest index value [9].

Similarly, data in (Table 3) showed that live mulch too had significant effect on harvest index value. The cowpea, moong and mash mulching were significantly superior over control (no mulch) plot. The maximum harvest index was obtained with cowpea mulching (30.5%) which was significantly better than mash mulching but statistically at par with moong mulching. Harvest index value in moong mulching was numerically higher than mash mulching but could not reach the level of statistically significance and remained at par with each other. The maximum harvest index was observed in cowpea mulching and the minimum was in control (no mulch) plot. The percent increase in harvest was 13.8, 11.5 and 7.0 in cowpea, moong and mash mulching respectively, over control treatment [10].

CONCLUSION

Results of the present field investigation may lead to the conclusion that maize yield was maximum in conventional method of irrigation. Regarding live mulch with legumes, maize yield increased significantly with all live mulch treatment than its sole yield. Among different live mulch highest yield and benefits were observed under cowpea live mulch.

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