Impact of Mulch and Irrigation Schedules on Yield and Quality of Spring Sunflower in Tarai Region of Northern India

Abstract

The field experiment was carried out at Forage Block, Instructional Dairy Farm, Nagla, G. B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) in spring 2019 to, study the effect of mulches and irrigation schedules on productivity and water use efficiency of spring sunflower (Helianthus annuus L.) in Mollisols of Uttarakhand (India). The experiment consisted of 03 levels of mulches i.e., control (no mulch), straw mulch @ 6t/ha and polythene mulch (black) in the main plot and 04 levels of irrigation schedules i.e., critical stages (button, flowering, and seed filling stage), 0.8, 1.0 and 1.2 IW/CPE ratios in subplots, was laid out in split-plot design with three replications. Significant seed yield was recorded under application of polythene mulch that was statistically at par with straw mulch. Seed yield was recorded 4.6% and 18.5% higher under polythene mulch than straw mulch and control, respectively. The polythene mulch produced significantly the highest stover yield that was non-significant with straw mulch.. Polythene mulch produced 8.10% and 10.4 % higher stover than straw mulch and control, respectively. Sunflower seed yield differed significantly among irrigation schedules. Irrigation applied at 1.2 IW/CPE produced significantly the highest seed yield that was 5.4, 11.1, and 14.8% greater than irrigation scheduled at 1.0, 0.8 IW/CPE, and critical stages, respectively. Among the irrigation schedules, stover yield was recorded 5.8, 8.0, and 10.8% higher under the 1.2 IW/CPE ratio than 1.0, 0.8 IW/CPE ratio, and critical stages, respectively. Overall, it is highlighted that polythene mulch gives significantly higher productivity and quality parameters. And 1.2 IW/CPE ratios give significantly the highest seed yield and higher protein content and oil content.

Key words: Heading, Irrigation Schedules, Mulch, Protien, Tarai, etc.

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Introduction

The world production of main oil crops is steadily increasing, mainly because of increment and increased use of oil crops in biofuel production and edible vegetable oils. From the attitude of sowing areas within the world, oil crops are only preceded by cereals in importance. Sunflower could be a day-neutral, short duration, drought, and salinity tolerant oilseed crop belonging to the aster family. Sunflower (*Helianthus annuus* L.) is a very important oilseed crop and is native to southern parts of the USA and Mexico. Sunflower ranks fourth next to soybean, groundnut, and rapeseed within the total production of oilseeds of the planet. Sunflower is cultivated in a vicinity of 25.3 million hectares with annual production and productivity of 35.6 million tonnes and 1410 kg per hectare, respectively within the world within the year 2012-13 (Anon., 2014). Now, the crop has been well accepted by the farming community thanks to its desirable attributes like short duration, photoperiod insensitivity, adaptability to a good range of soil and atmospheric condition, drought tolerance, lower seed rate, higher seed multiplication ratio, and top quality of edible oil. The cultivation of sunflower is basically confined to southern parts of the country comprising the states of Karnataka, Maharashtra, Tamil Nadu, and state. These four states contribute about 90 percent of total acreage and 78 percent of total production. However, recently sunflower has moved to northern parts of the country where the productivity is extremely high. Karnataka is that the leading sunflower-producing state within the country and contributes nearly 52 percent of the whole area and 40 percent of the entire production within the country. In India, sunflower is grown over a region of 0.22 M ha with production and productivity of 0.23 Million tonne and 1023 kg per hectare, respectively during the year 2020-21 (**Directorate of Economics & Statistics, 2021**). It's considered to be an exhaustive crop. While the realm under the sunflower crop is increasing, the productivity isn't on par with the cultivable area. Among the several reasons because of low productivity, inadequate and imbalanced nutrition of essential nutrients is taken into account as a serious one. The availability of water is decreasing day-by-day and therefore the share of water to agriculture is decreasing very sharply over the previous couple of decades (Kadasiddappa *et al*., 2015).

Among the assorted approaches used for scheduling irrigation, a modified meteorological approach supported the ratio of fixed amount of irrigation water (IW) and cumulative pan evaporation (CPE) has been found suitable for the guidance of irrigation scheduling to different crops (Parihar *et al*., 1976). Among different conservation practices, mulching is an important technique which is known for its beneficial impacts on the soil-plant systems. Several advantages of mulching on soil and crops are prevention of soil erosion and runoff loss, reduction in the evaporation loss of water, conservation of residual soil moisture, maintenance of soil temperature and improvement in the soil physical, biological and chemical properties over time (**Kumar *et al.*, 2000).** Sunflower hybrids responded very well to the management of irrigation and mulches **(Domber *et al.*, 2009). Tunio *et al.* (2007)** reported significant differences in seed germination; seed per head, seed index and seed yield due to different types mulch and irrigation frequencies. Finally it was concluded that plastic sheet mulch produced more yield by conserving more moisture and having effective weed control so, plastic mulch could be used as good option for reducing ET losses and improved seed yield.

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MATERIALS AND METHODS

Field experiment was conducted in spring 2019 at the Forage Block, Instructional Dairy Farm, Nagla, G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India. The purpose was to investigate the impact of mulches and irrigation schedules on the productivity and water use efficiency of spring sunflower (*Helianthus annuus* L.) in the Mollisols soil of Uttarakhand. The experimental site had silty clay loam soil with specific characteristics such as pH 7.13, electrical conductivity (EC) 0.20 ds/m, organic carbon content 0.68%, bulk density 1.57 g/cc, and available nutrients including nitrogen, phosphorus, and potassium at levels of 280.2, 25.2, and 215.2 kg/ha, respectively. The experiment included three levels of mulches: control (no mulch), straw mulch at a rate of 6 tons/ha, and black polythene mulch. Four levels of irrigation schedules were also examined: critical stages (button, flowering, and seed filling), 0.8, 1.0, and 1.2 IW/CPE ratios. The design of the experiment followed a split-plot layout with three replications. The previous crop grown at the site was dhaincha (Sesbania rostrata). The sunflower hybrid variety called 'DRSH-1' was sown manually with treated seeds using Carbendazim at a rate of 3g/kg seed. The plants were spaced in lines 60 cm apart with a seed-to-seed distance of 30 cm, and the plant-to-plant distance was adjusted after 10 days of sowing. The recommended chemical fertilizer dose of 120:60:40 N:P205:K20 kg/ha was applied, with half of the nitrogen and the full dose of phosphorus and potassium applied at sowing. The remaining nitrogen was top-dressed after 25 days of sowing at the first irrigation. Mulching was performed with oat straw at 6 tons/ha or black polythene sheet after the first common irrigation at 25 days of sowing, depending on the treatment. Irrigation was scheduled based on the IW/CPE ratio and critical stages of the crop. The cumulative pan evaporation (CPE) values were obtained from a USWB Class-1 open pan evaporimeter located at the crop weather observatory of the university. The crop was harvested when the lower portion of the heads turned yellowish-brown, the bracts dried, the seeds became dark brown, and the thalamus turned yellow. Observations on growth and yield attributes were recorded from five randomly selected plants in each plot. The seed yield was calculated based on the net plot area for each treatment and presented in kg/ha. Protein content was determined using the Kjeldahl method. The statistical analysis of the data for various growth, yield, and quality parameters was conducted using a split-plot design and the standard approach of Analysis of Variance (ANOVA) as described by Gomez and Gomez (1984).

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Result and Discussion

Growth attributes:

Effect of mulch:

The application of mulch had a significant effect on 50 % flowering with maximum and minimum days taken under polythene mulch and control, respectively, however, polythene mulch and straw mulch were found non-significant to each other. This might be due to an inadequate moisture regime under control. A significantly higher crop growth rate was recorded at 30-60 DAS under polythene mulch than straw mulch and control but it was significantly equal to straw mulch. Significantly lowest crop growth rate was recorded under control. 60 DAS to harvest, significantly highest crop growth rate was observed under polythene mulch followed by straw mulch and significantly lowest crop growth rate was recorded under control. 30-60 DAS, significantly higher relative growth rate was recorded under polythene mulch followed by straw mulch and control but both were non-significant with each other. Significantly lowest relative growth rate was observed under control. At 60 DAS-harvest, the relative growth rate was not affected significantly by mulches however the highest RGR was recorded under polythene mulch followed by straw mulch and under the lowest in the control treatment.

Effect of irrigation schedules

Effect of irrigation schedules the days taken to 50% flowering were affected greatly by irrigation schedules. The irrigation schedule at 1.2 IW/CPE took maximum while other irrigation schedules i.e. critical stages, 0.8 and 1.0 IW/CPE ratio took minimum days to 50 % flowering; however, all irrigation schedules had a non-significant effect on 50 % flowering. Early flowering was recorded due to a higher frequency of irrigation leading to the early formation of reproductive parts. The crop growth rate was influenced significantly by irrigation schedules. At 30-60 DAS, a significantly higher crop growth rate was recorded when irrigation was scheduled at 1.2 IW/CPE than 0.8, 1.0 IW/CPE, and critical stages, but it was statistically at par with 1.0 IW/CPE. Significantly the lowest crop growth rate was observed when irrigation was applied at critical stages. A similar trend was observed at 60 DAS to harvest where the highest crop growth rate value was recorded at irrigation scheduled at 1.2 IW/CPE and the lowest crop growth rate was observed when irrigation was applied at critical stages. The increasing irrigation frequency increased crop growth rate due to the availability of adequate soil moisture that supported higher cell divisions and expansion of cells (Ramamoorthy *et al.*, 2009). Irrigation schedules had a significant effect on RGR at both 30-60 DAS and 60 DAS harvest. Significantly the highest relative growth rate was found at the 1.2 IW/CPE ratio which remained non-significant with the 1.0 IW/CPE ratio. The lowest RGR was recorded when irrigation was applied at critical stages, though it was non-significant with 0.8 and 1.0 IW/CPE ratios. Similarly, at 60 DAS – harvest, significantly highest RGR was measured at 1.2 IW/CPE irrigation schedules that were

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statistically at par with 0.8 and 1.0 IW/CPE ratio. The higher value was attributed to more number of leaves as well as LAI.

Yield attributes and seed yield

Effect of mulch

The mulch application had a significant effect on sunflower seed yield. Significantly higher seed yield was recorded under application of polythene mulch that was statistically at par with straw mulch and significantly the lowest yield was found under control. The sunflower seed yield was recorded 4.6% and 18.5% higher under polythene mulch than straw mulch and control, respectively. The application of straw mulch also produced a 13.3% greater seed yield than control. The higher sunflower yield was due to greater head diameter, seed weight, 100 seed weight, and seed weight per head. Similar findings were also recorded by Arora *et al.*, (2011).

The polythene mulch produced significantly the highest stover yield that was non-significant with straw mulch. Significantly the lowest stover yield was observed under control. Polythene mulch produced 8.10% and 10.4 % higher stover than straw mulch and control, respectively. The higher stover yield was due to more plant height, the number of leaves, and dry matter accumulation. Din *et al.,* (2013) and Rajput *et al.,* (2014) also supported the above results. The mulch had a significant effect on the harvest index of sunflower and a significantly higher value of harvest index was recorded under polythene mulch that was statistically at par with straw mulch. Significantly the lowest harvest index was recorded under control. A higher harvest index recorded under polythene mulch might be due to a higher fraction of seed yield compared to stover yield.

Effect of irrigation schedules

Sunflower seed yield differed significantly among irrigation schedules. Irrigation applied at 1.2 IW/CPE produced significantly the highest seed yield that was 5.4, 11.1, and 14.8% greater than irrigation scheduled at 1.0, 0.8 IW/CPE, and critical stages, respectively. The seed yield didn't vary significantly between irrigation applied at critical stages and 0.8 IW/CPE ratio, however, irrigation scheduled at 1.0 IW/CPE ratio also gave a significantly higher seed yield than 0.8 IW/CPE ratio and critical stages. Such differences in the seed yield were attributed to favorable water regimes in soil for better mobilization of nutrients and also enhanced source capacity and sink strength which in turn influenced yield attributing characters. Gurumurthy et al. (2008) also recorded a higher yield of a sunflower when irrigation was applied at 1.2 IW/CPE mainly due to higher values of yield contributing attributes. The interaction effect between mulch and irrigation schedule was found non-significant. Among the irrigation schedules, significantly the highest stover yield was found when irrigation was scheduled at 1.2 IW/CPE followed by irrigation applied at 0.8 and 1.0 IW/CPE ratio. Significantly the lowest stover yield was produced at irrigation applied at critical stages. The stover yield was recorded as 5.8, 8.0, and 10.8% higher

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under the 1.2 IW/CPE ratio than 1.0, 0.8 IW/CPE ratio, and critical stages, respectively. The higher stover yield was attributed to higher values of growth and yield attributes. These results were also supported by Mahal *et al.* (2012). The interaction effect between mulch and irrigation schedules was found non-significant. The irrigation schedules did not have any significant effect on the harvest index however higher value of harvest index was recorded when irrigation was applied at 1.2 IW/CPE ratio followed by 1.0 and 0.8 IW/CPE ratio. The lowest harvest index was recorded at irrigation applied at critical stages.

Quality parameter:

Effect of mulch

The significantly highest oil content was recorded under polythene mulch but values of oil content were statistically at par grown under straw mulch and control. Higher oil content values were caused due to higher 100 seed weight favored by a better plant grown and development. **Sheikh *et al.* (2002)** also reported higher oil content under mulch application. Significantly higher oil yield was recorded under polythene mulch that was statistically similar to straw mulch. The oil yield was recorded 6.0 to 18.4% higher than straw mulch and control, respectively. Higher oil yield was the result of high oil content and seed yield. The above result was supported by **Yenpreddiwar *et al.* (2007).** The polythene mulch recorded significantly highest protein content followed by straw mulch and control. However, there was no significant difference between control and straw mulch. The higher protein content was attributed to higher nitrogen content in the seed. Similar findings were reported by **Jain *et al.* (2017).** Significantly highest protein yield was found under polythene mulch that remained non-significant with straw mulch and the lowest protein yield was found under control. The higher protein yield was the result of higher protein content and seed yield**. Hingonia *et al*. (2016)** also reported a similar agreement.

Effect of irrigation schedules

The oil content increased with increasing IW/CPE ratio and the highest value was recorded when irrigation was applied at 1.2 IW/CPE ratio but the oil content was found significantly similar at both 0.8 and 1.0 IW/CPE ratios. Significantly lowest oil content was extracted at irrigation scheduled at critical stages. The higher values of oil content might be due to better soil moisture caused higher availability and uptake of nutrients which in turn produced bold seed and greater seed test weight and it was supported by **Hittinahalli *et al.* (2007).** The interaction effect was found non-significant. The oil yield was increased with increasing irrigation frequencies with the significantly highest value at 1.2 IW/CPE ratio followed by 1.0 IW/CPE ratio. Significantly lowest oil yield was found when irrigation was applied at critical stages that remained statistically at par with a 0.8 IW/CPE ratio. The oil yield was recorded 10.9, 16.3, and 19.9% higher under the 1.2 IW/CPE ratio than 1.0 and 0.8 IW/CPE ratio as well as critical stages,

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respectively. This was ascribed due to better formation and development of seeds associated with higher oil content and seed yield. Similar results were also reported by **Hittinahalli *et al*., (2007).** The interaction effect was found non-significant. The irrigation schedules had a significant effect on protein yield and it was increased with increasing irrigation frequencies. The protein content increased with increasing irrigation frequencies and a significantly higher value was found at the 1.2 IW/CPE ratio followed by a 1.0 IW/CPE ratio that had a significantly higher value than irrigation schedules at critical stages and 0.8 IW/CPE ratio. The higher value was attributed to high N content under higher irrigation frequency favored by more N uptake. The interaction effect between mulch and irrigation schedules was recorded as non-significant. **Hussain *et al*. (2001**) also reported the same findings. Significantly highest protein yield was recorded under 1.2 IW/CPE ratio and irrigation scheduled at critical stages gave significantly lowest value that was non-significant with irrigation scheduled at 0.8 IW/CPE ratio. Higher protein yield was the result of higher protein content and seed yield. The same results were recorded by **Hussain *et al.* (2001)**. The interaction effect was found non-significant.

CONCLUSION

The results indicated that growth and yield attributes and seed yields of sunflower were highest under polythene mulching and also irrigation scheduled at1.2 IW/CPE ratio. On other hand, the scheduling irrigation at 1.2 IW/CPE ratios gave significantly higher in Quality parameter. It is, therefore, concluded that sunflower may be grown with application of straw mulch @ 6 ton/ha with irrigation Scheduled at 1.2 IW/CPE ratios for higher productivity, as well as protein and oil content during spring season in Uttrakhand and may also be replicated in similar agro-ecological zones of India.

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Table1. Effect of mulch and irrigation schedules on CGR, RGR, and 50% flowering of sunflower

Treatments	Crop growth rate ($g/m^2/day$)		Relative growth rate (g/g/day)		50 % flowering (Days)
	30-60 DAS	**60 DAS- at harvest**	**30-60 DAS**	**60 DAS- at harvest**	
A) **Mulch**					
Control	10.11	5.32	0.077	0.015	63
Straw mulch	10.45	5.75	0.079	0.018	64
Polythene mulch	10.50	5.90	0.083	0.020	65
SEm ±	0.03	0.02	0.010	0.023	0.16
CD (P=0.05)	0.10	0.08	0.030	NS	01
B) Irrigation schedules					
Critical stages	9.39	5.10	0.075	0.016	64
0.8	10.00	5.43	0.076	0.018	64
1.0	10.88	5.65	0.077	0.018	65
1.2	10.95	5.80	0.079	0.019	64
SEm±	0.05	0.05	0.001	0.001	0.24
CD (P=0.05)	0.20	0.18	0.002	0.003	NS

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Table 2. Effect of mulch and irrigation schedules on yield attributes and quality parameter

Treatments	Stover yield (kg/ha)	Seed yield (kg/ha)	Harvest index	Oil Percent %	Oil yield (kg/ha)	Protein (%)	Protein yield (kg/ha)
Control	7470.10	2594.54	25.50	37.50	885.00	17.79	461.71
Straw mulch	7483.64	2938.34	26.94	37.91	1015.05	17.87	525.43
Polythene mulch	8356.82	3074.30	27.56	38.81	1083.78	18.16	558.78
SEm ±	82.03	75.50	0.34	0.16	24.16	0.03	13.05
CD (P=0.05)	330.72	235.62	1.34	0.65	97.5	0.12	52.63
Critical stages	7367.00	2687.50	26.58	36.95	903.02	17.71	476.30
0.8	7674.52	2776.00	26.74	37.35	943.42	17.92	497.80
1.0	7698.52	2927.76	26.54	37.85	1004.15	18.02	527.88
1.2	8286.25	3085.00	26.81	40.16	1127.80	18.11	559.16
SEm±	59.42	39.54	0.37	0.22	16.42	0.02	7.25
CD (P=0.05)	177.94	118.50	NS	0.66	49.17	0.07	21.71

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