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Effect of Planting Patterns and Weed Control Treatments on Growth and Yield of Spring Maize

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ABSTRACT

Background: Weed infestation causes serious problem in the corn production and due to limiting land area different planting patterns are required to be adopted to meet the corn demand. A field trail was conducted during spring 2023 and 2024 on agricultural farm of Lovely Professional University, Punjab on "The effect of planting patterns and weed control treatments on weed biomass, growth and yield of spring maize (*Zea mays* L.)".

Methods: The study was laid out in split plot design with 3 planting methods *i.e.* flat planting with single row, flat sowing with paired row and ridge planting as main plots and five weed control treatments that is atrazine + pendimethalin *f. b.* straw mulching (6 t ha^{-1}), pendimethalin + intercropping cowpea *f. b.* earthing up and straw mulching, inter. dhaincha *f. b.* earthing up + straw mulching, two hand weeding and unweeded (control) in sub plots with four replications. Variety PMH10 was used is recommended for the spring season under Punjab conditions.

Result: The results indicated that among the planting patterns, the ridge planting produced significantly higher grain yield during both the years as compared to flat sowing with single row and paired row which was due to better growth parameters in ridge sowing. However, the weed biomass was found significantly less in the ridge planting compared to flat planting. Among subplot treatments, the higher grain yield was obtained in treatments that are pendimethalin + intercropping of cowpea *f. b.* earthing up + straw mulching and intercropping dhaincha *f. b.* earthing up + straw mulching which were statistically at par with one another during 2023 and 2024 and both treatments were found to be significantly better than all other treatments. The grain yield was significantly less in the unweeded (control) treatment as compared to other treatments. The weed density and biomass was significantly less in the treatments in which mulching was used as compared to two hand weeding and the control treatments.

Key words: Maize, Mulching, Planting patterns, Weeds, Yield.

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crop cultivated throughout the world due to highly versatile and having wider adaptability. India ranks 7th in maize production. In Punjab, maize was grown on 1.07 lakh ha land with 3.95 lakh tonnes of production. Productivity of maize under Punjab conditions is 36.65 q ha^{-1} (Anonymous, 2022). Maize is not only utilized for human consumption, feed and fodder purpose but also used in the preparation of some industrial products like oil, protein, food sweeteners, pharmaceutical, cosmetic, textiles, package and paper industries (Kumar and Walia, 2003).

The land has been limiting factor to meet the growing food demand as different planting methods needs to be investigated to improve the overall production. The maize crop can be cultivated under different planting patterns like ridge planting, raised bed sowing, single row planting, paired row planting *etc*. The ridge sowing optimizes the canopy structure of the crop which enhances light interception, thus increasing the yield of crop (Liu *et al.,* 2018). The maize yield improved with the ridge furrow planting along with mulching which suppressed the weeds and allowed the crop to growth with minimum competition (Jia *et al.,* 2018). The use of varying planting pattern may also impact the weed infestation and losses due to weeds.

The growth and development of this crop is impacted by both biotic and abiotic factors. Weeds can cause yield loss ranging from 28-93% depending on soil, climate, management practices and adoption of weed control methods. The economic loss in maize crop due to weeds can be around 25.3% which is a very serious problem (Gharde *et al.*, 2018). Weeds compete with crop for all growth factors like nutrients, moisture, light, space *etc.* The yield loss ranged from 27-60% in maize crop due to weed infestation in eastern states (Moinuddin *et al.,* 2018). Straw mulching also helps in reducing the weed density as it impairs the direct sunlight and covers the soil surface which impacts the weed seed germination (Ezung *et al.,* 2018). Green manuring crops like dhaincha, cowpea, sunhemp, *etc*. not only helps to smother weed growth but also

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improves soil nitrogen by fixing atmosphere nitrogen with the help of root nodules. Integrated weed management practices significantly reduces the weed infestation and improves the grain yield in maize (Kumawat *et al.,* 2019). So, the planting pattern along with different weed control treatments can help to improve the maize yield.

MATERIALS AND METHODS

The trail was carried out at Agricultural Farm of Lovely Professional University, Punjab during spring 2023 and 2024. The experiment was laid out in split plot design with three planting methods in main plots *i.e.* flat sowing with single row, flat sowing with paired row and ridge sowing and five weed control treatments in sub plots *i.e.* atrazine + pendimethalin (0.75+0.75 kg/ha), pre-em. *f.b.* straw mulching, pendimethalin (0.60 kg ha^{-1}), pre-emergence+ intercropping cowpea (*Vigna unguiculata*) *f. b.* earthing up (EU) and straw mulching (SM), intercropping dhaincha (*Sesbania aculeata) f. b.* EU and SM, 2 hand weedings (4 and 6 week after sowing "WAS") and Unweeded (control) with four replications. The field was prepared with disc plough followed by rotavator and sowing was done by dibbling method. The maize variety PMH10 was sown on 18th February 2023 and 20th February 2024. The row to row spacing was 60 cm in single row and ridge sowing. However, in paired row sowing, the two adjacent rows at 30 cm apart with spacing of 90cm between two pairs were kept. The plant to plant spacing was kept same *i.e.* 20 cm in each method. The plant population was uniform among all the planting patterns. The gross plot size was 4.5 m × 4 m. The full dose of SSP at 370 kg/ha was broadcasted at time of field preparation. The nitrogen @ 125 kg/ha was applied in three splits with 1/3rd dose in each split at 15, 25 and 35 days after sowing (DAS). The spray of pre-emergence herbicides was done on the same day after the sowing. The intercrops were also sown with kera method. The intercrops were cut and laid out along the rows followed by earthing up and straw mulching (6 t/ha) after 45 DAS. To control the fall armyworm, Emamectin benzoate was sprayed a rate of 0.4 ml/l at 20 DAS, with subsequent applications 7 days interval.

The studied traits:

a. Weed count (m^{-2}), weed dry matter accumulation (q/ha) and weed control efficiency (WCE) (%) were recorded at 105 days after sowing (DAS).
b. Plant height (cm), dry weight per plant (g), grain yield (q/ha) and biological yield (q/ha) were recorded at harvest.

The crop was harvested with sickle at 120 DAS when grain hardening took place and leaves of the crop dried up. The maize plants (20 plants) were sun dried for 5 days and weighed on weighing balance, then the cob sheath was removed and shelling was done with hands. The analysis of the data was done with OPSTAT at 0.5% level of significance.

RESULTS AND DISCUSSION

Effect of planting methods on weed count, weed dry matter accumulation and WCE

The data for weed density is presented in the Table 1 and data indicated that number of weeds was significantly lesser in the ridge planting as compared to flat sowing and paired row sowing when recorded at 105 DAS during both the years. The higher weed count in the paired row planting may be due to the wider spacing available in two

Table 1: Effect of planting patterns, weed control treatments and their interactions on weed count, weed dry weight and WCE at 105 DAS.

Treatments	Weed count (m^{-2})		Weed dry weight (q/ha)		Weed control efficiency (%)*	
	2023	2024	2023	2024	2023	2024
Planting patterns						
Flat sowing with single row	8.7 (119)	7.8 (95)	2.6 (9)	2.3 (7)	58.73	62.90
Flat sowing with paired rows	10.0 (157)	8.9 (126)	2.8 (12)	2.9 (15)	55.56	53.23
Ridge sowing	8.4 (110)	7.1 (80)	2.5 (8)	2.1 (7)	60.32	66.13
SE(m) ±	0.17	0.22	0.03	0.11	-	-
C.D. at 5%	0.61	0.76	0.10	0.38	-	-
Weed control treatments						
Pendi.+Atz., pre-em *f. b.* SM	10.6 (113)	8.4 (71)	2.0 (3)	1.3 (1)	68.25	79.03
Pendi., pre-em+inter. cowpea *f. b.* EU and SM	1.0(0)	1.0(0)	1.0(0)	1.0 (0)	84.13	83.87
Inter. dhaincha f. *b.* EU and SM	1.0(0)	1.0(0)	1.0(0)	1.0 (0)	84.13	83.87
Two hand weedings (4 and 6 WAS)	15.2 (231)	13.5 (182)	2.8 (7)	2.6 (6)	55.56	58.06
Unweeded (control)	17.3 (299)	15.7 (249)	6.3 (38)	6.2 (41)	-	-
SE(m) ±	0.16	0.17	0.06	0.16	-	-
C.D. at 5%	0.47	0.50	0.16	0.47	-	-
Interaction C.D. at 5%	NS	NS	NS	NS	-	-

Note: EU- Earthing up and SM- Straw mulching. *WCE is based on transformed data.

adjacent pairs which also lead to lower WCE in paired row sowing. Similar findings were reported by Abdullah *et al.* (2008), who stated that the weed density and dry weight was lower under the ridge planting and was statistically at par with flat sowing with single row.

The weed dry matter was significantly less in ridge sowing than flat sowing and paired row sowing during 2023 and 2024, respectively. The highest weed dry matter was found in paired row planting. The change in land configuration impacts the weed germination. The lesser weed count under ridge planting may also be due to the deeper placement of weed seeds during the ridge formation which impacted the weed germination (Walia *et al.,* 2007).

The highest WCE of 60.32 and 66.13% was recorded in ridge sowing during 2023 and 2024, respectively whereas the WCE was 58.73 and 62.90% in the flat sowing with single row during both the years, respectively. The higher weed control efficiency in the ridge sowing can be attributed to the less weed count which resulted in lesser weed try matter than other cropping patterns.

Effect of weed control treatments on weed count, weed dry matter accumulation and WCE

Among the weed control treatments, pendimethalin, pre-em + intercropping cowpea *f. b.* EU and SM and inter. dhaincha *f.b.* EU and SM recorded significantly less weeds than other treatments. The unweeded (control) recorded significantly higher number of weed during both the years as compared to all the other treatments. Incorporation of green manures followed by earthing up and straw mulching showed no weed population at 105 DAS. In pendimethalin + atrazine *f.b.* straw mulching, the weed count and dry matter were less than two hand weedings and control. It may be due to covering of soil surface with mulching which did not allowed the weeds to germinate initially. The results are almost similar to the findings of Asif *et al.* (2020) and Tahir *et al.* (2009).

Unweeded (control) had significantly higher dry matter of weed as compared to all other weed control treatment. There was no weed dry matter in pendimethalin + intercropping cowpea *f. b.* EU and SM and intercropping dhaincha *f. b.* EU and SM as there were no weed population at 105 DAS. The weed dry matter in pre-emergence herbicide spray *f. b.* straw mulching was also lower than two hand weedings and unweeded (control). The decrease in weed count and weed dry weight by integrated weed control was also reported by Walia *et al.* (2007). The lower weed count and restricting the weed growth due to weed control methods results in lower weed dry matter than unweeded control treatments (Rani *et al.,* 2022).

Among the weed control treatments, WCE was highest in pendimethalin + intercropping cowpea *f. b.* EU and SM and intercropping dhaincha *f. b.* EU and SM *i.e*. 84.13 and 83.87% during 2023 and 2024, respectively. The WCE was lower in the two hand weeding (4 and 6 WAS). The higher WCE in integrated weed control treatments can be attributed to lower weed dry matter accumulation. Similar results were reported by Revathi *et al.* (2012). Integrated weed management strategies provide higher weed control efficiency by reducing the weed population and growth (Kumawat *et al.,* 2019).

Effect of planting methods on plant height and dry weight per plant

The growth data presented in Table 2 shows that the height of plant and dry weight per plant was significantly influenced by planting methods and weed control treatments. Among planting patterns, the plant height was significantly higher

Table 2: Effect of planting patterns, weed control treatments and their interactions on plant height and dry matter accumulation/plant at harvest.

Treatments	Plant height (cm)		Dry weight/ plant (g)	
	2023	2024	2023	2024
Planting patterns				
Flat sowing with single row	179.0	183.1	257.9	290.4
Flat sowing with paired rows	174.1	172.8	238.1	268.7
Ridge sowing	181.3	184.4	261.9	298.2
SE(m) ±	1.35	0.55	5.04	5.32
C.D. at 5%	4.76	1.95	17.77	18.76
Weed control treatments				
Pendi. + Atz., pre-em *f. b.* SM	183.7	185.9	261.2	303.6
Pendi., pre-em+inter. cowpea *f. b.* EU and SM	187.7	188.8	281.3	321.0
inter. dhaincha *f. b.* EU and SM	186.2	188.4	272.4	321.8
Two hand weedings (4 and 6 WAS)	177.1	179.3	252.1	291.2
Unweeded (control)	155.8	158.2	196.1	191.2
SE(m) ±	0.99	1.22	7.20	3.74
C.D. at 5%	2.84	3.51	20.72	10.77
Interaction C.D. at 5%	NS	NS	NS	NS

Note: EU- Earthing up and SM- Straw mulching.

in ridge sowing and flat sowing as compared to paired row sowing during both the years. Belachew and Abera (2010) reported that the increased plant height in ridge sowing may be due to better soil conditions.

The dry matter accumulation per plant was also significantly higher in ridge sowing and flat sowing methods than paired row planting whereas the former treatments were found at par. As the weed competition is less in the ridge planting, so the crop utilized all the resources better which improved the growth parameters like plant height and dry weight per plant. Similar results were reported by Bakht *et al.* (2006) who found that plant fresh weight was improved in ridge sowing. Leguminous green manuring crops fixes the atmospheric nitrogen and covers the soil which reduces the weed growth at early stages and after incorporation provide nutrient to the crop which improves the growth and yield of the crop (Islam *et al.,* 2018).

Effect of weed control treatments on plant height and dry weight per plant

Among sub plots, plant height was significantly higher in pendimethalin, pre-em + intercropping cowpea *f.b.* EU and SM and intercropping dhaincha *f.b.* EU and SM was statistically at par with the former treatment. The minimum plant height was observed in the unweeded (control) treatment during both the years. Similar results were reported by Asif *et al.* (2020) who reported that the increased plant growth may be due to suppressed weed growth by mulching which could have limited the weed growth and maize plant took advantage of space and the nutrients.

The dry weight per plant was significantly higher in the intercropping treatments *f. b.* earthing up and straw mulching. The significantly less dry matter plant^{-1} was recorded in the unweeded (control) during both years. Rao *et al.* (2009) reported that maize growth increased significantly due to lesser weed biomass under various weed control treatments. The interactive effect of planting methods and weed control treatments remained non-significant during both years.

Effect of planting methods on grain yield and biological yield

Table 3 shows the impact of planting patterns and weed control treatments on the grain yield and biological yield of maize crop. Among the planting patterns, the significant higher grain yield (83.3 and 85.6 q/ha) was observed in ridge sowing than flat sowing (81.3 and 84.0 q/ha) and paired row sowing (76.2 and 78.0 q/ha) during both the years, respectively. The average increase in grain yield was 9.53% in ridge sowing as compared to paired row sowing. The results are in accordance to findings of Zamir *et al.* (2012) who stated that sowing of maize on ridges perform better than other methods due to better moisture availability and micro environment.

The biological yield was significantly higher in the ridge planting as compared to flat sowing during both the years. The lowest biological yield during the both years was observed in the paired row planting. Biological yield is the combined result of all the growth parameters as it is higher in ridge sowing that may be due to the fact that plant height and dry weight per plant was higher under ridge sowing due to better soil conditions and lesser weed competition than other sowing methods. Liu *et al.* (2018) reported the similar finding and stated that the increase in yield under ridge planting can be due to increased soil moisture and better soil temperature conditions.

Table 3: Effect of planting patterns, weed control treatments and their interactions on grain yield and biological yield at harvest.

Treatments	Grain yield (q/ha)		Biological yield (q/ha)	
	2023	2024	2023	2024
Planting patterns				
Flat sowing with single row	81.3	84.0	257.4	267.9
Flat sowing with paired rows	76.2	78.0	247.2	247.8
Ridge sowing	83.3	85.6	263.9	278.9
SE(m)±	1.52	1.42	3.28	3.65
C.D. at 5%	5.36	5.02	11.58	17.12
Weed control treatments				
Pendi. + Atz., pre-em *f. b.* SM	82.3	84.7	265.9	263.8
Pendi., pre-em+inter. cowpea *f. b.* EU and SM	87.7	89.4	285.0	292.8
inter. dhaincha *f. b.* EU and SM	90.7	92.4	277.1	294.8
Two hand weedings (4 and 6 WAS)	77.3	82.7	250.2	258.0
Unweeded (control)	63.2	63.7	202.8	214.8
SE(m)±	1.53	1.28	3.50	3.89
C.D. at 5%	3.32	3.69	10.08	11.20
Interaction between planting patterns and weed control treatments C.D. at 5%	NS	NS	NS	NS

Note: EU- Earthing up and SM- Straw mulching.

Effect of weed control treatments on grain yield and biological yield

Among the weed control treatments, the grain yield of 90.7 and 92.4 q/ha was recorded in inter. dhaincha *f. b.* EU and SM and 87.7 and 89.4 q/ha in pendimethalin, pre-em+inter. cowpea *f. b.* EU and SM during 2023 and 2024, respectively. Both treatments produced significantly better yield than other weed management treatments. Significantly less grain yield was observed in unweeded (control) during both years as compared to all the other treatments. Shah *et al.* (2013) reported similar finding and stated the organic mulches reduces the weed growth and increases moisture content and enhances the grain productions. Straw mulching keeps the weed population in check for the longer period of time which helps in improving the grain yield of maize (Chaudhary *et al.,* 2024).

Among the subplot treatments, highest biological yield (285.0 q/ha) was found in inter. dhaincha *f. b.* EU and SM which was statistically at par with pendi., pre-em + inter. cowpea *f. b.* EU and SM (277.1 q/ha) in 2023. However, the biological yield was highest in inter. dhaincha *f. b.* EU and SM (294.8 q/ha) followed by pendimethalin, pre-em + inter. cowpea *f. b.* EU and SM (292.8 q/ha) in 2024 which was at par and significantly superior treatment. The biological yield remained significantly less during both the years in unweeded (control) treatment as compared to other weed control treatments. Liu *et al.* (2018) also stated that using mulches help to control weed and improved soil moisture which results in better growth and yield in the maize crop. Similar results were reported by Nimanwad *et al.* (2022). The interaction of planting pattern and weed control treatments remained non-significant in both years.

CONCLUSION

It can be concluded that among the planting patterns, the growth and yield of maize was better under the ridge sowing due to lesser weed competition and growth parameters than the flat sowing. In the weed control treatments, the use of intercrops, earthing up and straw mulching significantly reduced the weed biomass than two hand weeding and control which resulted in enhanced growth and higher grain yield. So, the integration of various weed control methods can be successful for reducing losses due to weeds and somewhat changing the planting methods also influence the weed infestation.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

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