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Response of Maize Crop to Deficit Irrigation and Planting Methods

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Abstract

Irrigation and planting methods are considered some of the important factors affecting yield of maize. To evaluate the effect of different Irrigation levels and planting methods on the performance of maize, an experiment was conducted at Agronomy research farms of The University of Agriculture Peshawar during summer 2017. The experiment was laid out in Randomized complete Block design with split plot arrangement having four replications. Deficit irrigations (Full, one missing at six leaves stage, one missing at twelve leaves stage, one missing at flowering stage, one missing at grains fillings stage) were allotted to main plots and planting methods (Ridge, flat, broadcast) were assigned to sub plots. Deficit irrigation had significant effect on plant stem thickness, Ear weight, ear length, plant height, cob height above the soil and biological yield. Highest plant stem thickness (1.98cm), Ear weight (106.42g), ear length (16.45cm), plant height (199cm), cob height above the soil (87cm) and biological yield (13433.25kg ha-1) were attained from Full irrigation. Planting method had significant effect on plant stem thickness, No of leaves plant-1, No of Nodes plant-1, ear weight, ear length, plant height, cob height above the soil, biological yield. Highest plant stem thickness (1.82), No of leaves plant-1 (15), No of Nodes plant-1 (7), ear weight (102.15), ear length (15.50), plant height (196.10), cob height above the soil (86.10), biological yield (11899.90) were attained from ridge planting method. It is concluded that Ridge planting method give a positive response in majority of the parameters and improve maize yield. Among deficit irrigations, deficit irrigation at tasseling and grain filling stage significantly reduce yield of maize.

Keywords: Deficit irrigation; Planting method and Maize; Biological yield

Introduction

Maize (*Zea mays* L.) is a monoecious plant of poacea family and is extensively grown in temperate, subtropical and tropical regions of the world. Its range of adaptation stretches from 50° N to 40° S latitude and can be grown at an altitude from sea level to 3300 meters above sea level [1]. In Pakistan, during 2014, it was cultivated on 1168.5 thousand hectares with total production of 4944.5 thousand tones and productivity of 4317kg ha^{-1} [2]. Maize is the second most important crop after wheat in Khyber Pakhtunkhwa (KPK) of Pakistan. It is used as a fodder in a majority of the farming systems and staple food in the rural areas of the province, especially at high altitudes. It is also used in industries for making starch, oil, polishes, etc. [3]. During 2014, maize was grown on 470.9 thousand hectares in KPK with total production of 914.8 thousand tones and productivity of 1943kg ha^{-1} [2]. The reasons for low production include poor soil preparation, weed infestation, inefficient irrigation system and water scarcity.

In recent years water resources and planners and researchers have diverted their attention towards deficit irrigation which has been widely recognized as a valuable strategy for dry regions [4]. Deficit irrigation maximizes water productivity, which is the main limiting factor. In other words, the aim of deficit irrigations to stabilize yield and to get high field water application efficiency [5]. Pereira et al. [5] while working in cornell, USA reported that up to 60% deficit irrigation application resulted in only 13% wheat grain yield reduction.

Deficit irrigation progressively affected the productivity of water, generally with adequate harvest quality, allows efficient economic planting and consistent income due to stabilization of the harvest in comparison with rain fed cultivation. It also decreases the risk of certain diseases like in high humidity (e.g. fungi) in contrast with full irrigation. To make water resource-saving techniques workable for farmers in Pakistan and getting higher water productivity, crop should be cultivated under a certain level of deficit irrigation because every crop has a critical limit up to which it can tolerate water deficit, but after the limit it starts losses in growth and yield. Similarly, [6] reported that mild stress had less effect on photosynthesis but moderate and sever water stress significantly decreases photosynthesis. The loss in grain yield by deficit irrigation can be covered by using better sowing methods and soil moisture conservation practices in combination with deficit irrigation.

Materials and Methods

The experiment was conducted at the research farms of The University of Agriculture Peshawar during summer 2017. The experiment was laid out in RCBD with split plot arrangement having four replications. The experiment comprised of two factors: Factor A. Deficit Irrigation in which irrigations I1= Full irrigation, I2= one missing at six leaves stage, I3= one missing at twelve leaves stage I4= one missing at flowering stage I5= one missing at grains fillings stage at were allotted to main plots, while planting methods PM1= Ridge, PM2= flat, PM3= broadcast) was allotted to sub plots. The size of sub plot was 14m^2 (4m × 3.5m). Each subplot consists of 5 rows having 70cm row-to-row and 20cm plant-to-plant distance. The recommended rate of NPK (120-60-0Kg ha^{-1}) were applied uniformly to all plots. Full P and half N was at the time of sowing and half N was applied before flowering. Different cultural operations were performed such as thinning, weeding and pesticide application when needed in order to keep the plants healthy and active during the whole life cycle of the crop. The crop was sown (Azam Variety) on 26th of June 2017 and was harvested during the month of September 2017.

Statistical Analysis

For statistical analysis of the recorded data, analysis of variance procedure was followed according to RCBD split plot. Means was compared using least significant differences (LSD) test at P≤ 0.05 upon significant F-test [7].

Results

Plant stem thickness

Table 1: Plant stem thickness as influenced by planting methods and levels of irrigations.

Deficit Irrigations	Planting Methods			Means
	Ridge Planting	Flat Planting	Broadcast Planting	
Irrigation 1	2.23	1.95	1.75	1.98^a
Irrigation 2	1.58	1.35	0.98	1.30^c
Irrigation 3	1.6	1.23	0.85	1.23^c
Irrigation 4	1.78	1.55	1.33	1.55^{bc}
Irrigation 5	1.93	1.75	1.69	1.79^{ab}
Means	1.82^a	1.57^b	1.32^c	

Irrigation 1 = Full irrigation (10 irrigations).
Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).
Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).
Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).
Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).
LSD value for irrigation at ≤ 0.05=0.034.
LSD value for planting methods at ≤ 0.05=0.024.

Data regarding plant stem thickness as affected by planting methods and deficit irrigation are presented in Table 1. Analysis of the data showed that irrigation and planting methods has significantly affected stem thickness. The interaction was non-significant. Mean values of irrigation showed that maximum stem thickness (1.98cm) was recorded from full irrigation (10 irrigations) and minimum plant stem thickness (1.23cm) was observed from deficit irrigation (one irrigation missing at twelve leaves stage). Mean values of planting methods showed that maximum stem thickness (1.82cm) was recorded in ridge planting and minimum plant stem thickness (1.32cm) was noted from broadcast planting method.

Ear weight (g)

Table 2: Ear weight as influenced by planting methods and levels of irrigations.

Deficit Irrigations	Planting Methods			Means
	Ridge Planting	Flat Planting	Broadcast Planting	
Irrigation 1	110.5	107	101.75	106.42^a
Irrigation 2	109	105.7	100.38	105.03^{ab}
Irrigation 3	107.95	104.33	99.15	103.81^b
Irrigation 4	91.05	87.55	82.2	86.93^c
Irrigation 5	92.25	84.25	80.5	85.67^c
Means	102.15^a	97.77^b	92.80^c	

Irrigation 1 = Full irrigation (10 irrigations).

Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).

Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).

Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).

Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).

LSD value for irrigation at ≤ 0.05 =0.499.

LSD value for planting methods at ≤ 0.05 =0.234.

Data regarding Ear weight (g) as affected by planting methods and deficit irrigation are presented in Table 2. Analysis of the data showed that irrigation and planting methods has significantly affected ear weight (g). The interaction was found non-significant. Mean values of irrigation showed that maximum ear weight (106.42g) was recorded from full irrigation (10 irrigations) and minimum ear weight (85.67g) was observed from deficit irrigation (one irrigation missing at grain filling stage). Mean values of planting methods showed that maximum ear weight (102.15g) was recorded from ridge planting and minimum ear weight (92.80g) was noted from broadcast planting method.

Ear length (cm)

Ear length (cm) of maize as affected by planting methods and levels of irrigation are presented in Table 3. Analysis of the data showed that irrigation and planting methods has significantly affected ear length (cm). The interaction was non-significant. Mean values of irrigation showed that maximum ear length (16.45cm)

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was recorded from Full irrigation (10 irrigations) and minimum ear length (12.78cm) was observed from Deficit irrigation (one irrigation missing at grain filling stage). Mean values of planting methods showed that maximum ear length (15.50cm) was recorded from ridge planting and minimum ear length (14.08cm) was noted from Broadcast planting method.

Table 3: Ear length (cm) as influenced by planting methods and levels of irrigations.

Deficit Irrigations	Planting Methods			Means
	Ridge Planting	Flat Planting	Broadcast Planting	
Irrigation 1	17.45	16.45	15.45	16.45[a]
Irrigation 2	16.7	16.2	15.08	15.99[b]
Irrigation 3	16.18	15.68	14.95	15.60[c]
Irrigation 4	13.7	13.18	12.73	13.20[d]
Irrigation 5	13.45	12.7	12.2	12.78[e]
Means	15.50[a]	14.84[b]	14.08[c]	

Irrigation 1 = Full irrigation (10 irrigations).

Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).

Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).

Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).

Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).

LSD value for irrigation at ≤ 0.05 =0.112.

LSD value for planting methods at ≤ 0.05 =0.109.

Plant height (cm)

Table 4: Plant height (cm) as influenced by planting methods and levels of irrigations

Deficit Irrigations	Planting Methods			Means
	Ridge planting	Flat planting	Broadcast planting	
Irrigation 1	202	199.75	196	199.25[a]
Irrigation 2	186	184.5	182	184.17[c]
Irrigation 3	194.75	188.25	186.5	189.83[bc]
Irrigation 4	198	194.25	190.25	194.17[ab]
Irrigation 5	199.75	196.25	194	196.67[ab]
Means	196.10[a]	192.60[b]	189.75[b]	

Irrigation 1 = Full irrigation (10 irrigations).

Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).

Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).

Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).

Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).

LSD value for irrigation at ≤ 0.05=2.186.

LSD value for planting methods at ≤ 0.05=0.720

Plant height (cm) of maize as affected by levels of irrigations and planting methods are presented in Table 4. Analysis of the data showed that irrigation and planting methods has significantly affected Plant height (cm). The interaction was non-significant. Mean values of irrigation showed maximum Plant height (199.25cm) from treatment of Full irrigation (10 irrigations) and minimum Plant height (184.17cm) was observed from Deficit irrigation (one irrigation missing at six leaves stage). Mean values of planting methods showed that highest plant height (196.10cm) was recorded in ridge planting and lowest plant height (189.75) was noted from Broadcast planting method.

Cob height above the soil (cm)

Table 5: Cob height above the soil (cm) as influenced by planting methods and levels of irrigations.

Deficit Irrigations	Planting Methods			Means
	Ridge Planting	Flat Planting	Broadcast Planting	
Irrigation 1	92	89.75	82	87.92[a]
Irrigation 2	76	74.5	67.5	72.67[c]
Irrigation 3	84.75	78.25	72.25	78.42[bc]
Irrigation 4	88	84.25	76.75	83.00[ab]
Irrigation 5	89.75	86.25	80	85.33[a]
Means	86.10[a]	82.60[b]	75.70[c]	

Irrigation 1 = Full irrigation (10 irrigations).

Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).

Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).

Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).

Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).

LSD value for irrigation at ≤ 0.05=1.676.

LSD value for planting methods at ≤ 0.05=0.707.

Cob height above the soil (cm) of maize as affected by levels of irrigations and planting methods are presented in Table 5. Analysis of the data showed that irrigation and planting methods has significantly affected cob height above the soil (cm). The interaction was non-significant. Mean values of irrigation showed that maximum cob height above the soil (87.92cm) was recorded from Full irrigation (10 irrigations) and minimum cob height above the soil (72.67cm) was observed from Deficit irrigation (one irrigation missing at six leaves stage). Mean values of planting methods showed that maximum cob height above the soil (86.10cm) was recorded in ridge planting and minimum cob height above the soil (75.70cm) was noted from Broadcast planting method.

Biological yield (kg ha^{-1})

Biological Yield (kg ha^{-1}) of maize as affected by levels of irrigations and planting methods are presented in Table 6. Analysis of the data showed that irrigation and planting methods has significantly affected biological Yield (kg ha^{-1}). The interaction was non-significant. Mean values of irrigation showed that maximum biological Yield (13433.25kg ha^{-1}) was recorded from Full irrigation (10 irrigations) and minimum biological Yield (9119.50kg ha^{-1}) was observed from Deficit irrigation (one irrigation missing at six leaves stage). Mean values of planting methods showed that

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maximum biological yield (11899.90kg ha^{-1}) was recorded from ridge planting and minimum biological yield (10819.60kg ha^{-1}) was noted from Broadcast planting method.

Table 6: Biological Yield (kg ha^{-1}) as influenced by planting methods and levels of irrigations.

Deficit Irrigations	Planting Methods			Means
	Ridge Planting	Flat Planting	Broadcast Planting	
Irrigation 1	13610.75	13687	13002	13433.25^a
Irrigation 2	9569	9132.25	8657.25	9119.50^e
Irrigation 3	10625	10232	10064	10307.00^d
Irrigation 4	12424.75	11201.25	11063.25	11563.08^c
Irrigation 5	13270	12283.75	11311.5	12288.42^b
Means	11899.90^a	11307.25^b	10819.60^c	

Irrigation 1 = Full irrigation (10 irrigations).

Irrigation 2 = Deficit irrigation (one irrigation missing at six leaves stages).

Irrigation 3 = Deficit irrigation (one irrigation missing at twelve leaves stage).

Irrigation 4 = Deficit irrigation (one irrigation missing at flowering stage).

Irrigation 5 = Deficit irrigation (one irrigation missing at grain filling stage).

LSD value for irrigation at ≤ 0.05 =118.933.

LSD value for planting methods at ≤ 0.05 =95.687.

Discussion

The data collected in accordance with the procedure outlined in materials and methods, which are further described in experimental results in previous chapter, are discussed in the light of literature collected for the purpose of clarification and comparison. Data regarding plant stem thickness as affected by planting methods and levels of irrigation presented in the previous chapter showed that deficit irrigation and planting methods had significantly affected plant stem thickness. Plots applied with full irrigation results in maximum plant stem thickness compared with plot having one irrigation missing at twelve leaves stage. These results are in agreement with those of [8] who reported maximum plant stem thickness with levels of irrigations. Plant stem thickness increased with ridge planting method compared with broad cast method. Same finding was reported by [9]. They reported that maximum plant stem thickness from ridge planting method.

Data regarding ear weight presented in previous chapter showed that irrigation and planting methods had significantly affected ear weight. In case of irrigation, maximum ear weight was recorded in plots applied with Full irrigation while minimum ear weight was observed in plots with one irrigation missing at grain filling stage. These results are in agreement with those of [4] who reported highest ear weight from full irrigation. Ear weight increased with ridge planting compared with Broadcast method. Same finding was reported by [10] they reported that ear weight was increased with planting maize crop on ridges.

Analysis of data revealed that ear length was remarkably affected by irrigation and planting methods. Plots with full irrigation results in maximum ear length compared with plot having one irrigation missing at grain filling stage. These results are in agreement with those of [11] and [12] who reported increase in ear length with full irrigation. Highest ear length was observed with ridge planting method compared with broad cast method. Similar results were obtained by [11] they reported that ear length was increased with planting maize crop on ridges.

Data regarding plant height presented in previous chapter showed that irrigation and planting methods had significantly affected plant height. In case of irrigation, the maximum plant height recorded from plots applied with Full irrigation while minimum plant height was observed in plots with one irrigation missing at six leaves stage. Same finding was obtained by [13]. Plant height was increased with ridge planting compared with Broadcast method. Huang et al. [9] Recorded the same result regarding increase in plant height with ridge planting.

Cob height above soil was significantly affected by irrigations and planting methods. Highest cob height above soil was recorded in plots applied with Full irrigation while minimum cob height above soil was observed in plots having one irrigation missing at six leaves stage. These results are in agreement with those of [8]. They reported maximum cob height above soil by providing full irrigation. Cob height above soil was increased with ridge planting compared with Broadcast method. Kilic [14] Reported the same result regarding increase in cob height above soil with ridge planting.

Data regarding Biological yield as affected by planting methods and deficit irrigation presented in previous chapter showed that irrigation and planting methods had significantly affected biological yield. In case of irrigation, the highest biological yield recorded from plots applied with full irrigation while lowest biological yield was observed in plots with one irrigation missing at six leaves stage. Same finding was obtained by [13]. Biological yield was increased with ridge planting compared with broadcast method. Bakht et al. [15] Concluded that ridge sown maize produced maximum biological yield.

Conclusion

On the basis of findings obtained in this research study. It is concluded that:

a. Ridge planting method give a positive response in majority of the parameters and improve maize yield.

b. Among deficit irrigations, deficit irrigation at tasseling and grain filling stage significantly reduce yield of maize.

Deficit irrigation at 6 leaves stage were resulted in reduction of vegetative growth.

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