Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Juniper PUBLISHERS
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Research Article
Volume 15 Issue 2 - April 2018
DOI: 10.19080/ARTOAJ.2018.15.555947

Agri Res & Tech: Open Access J

Effect of Salicylic Acid on Yield and Yield Components of Maize under Reduced Irrigation

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Submission: March 01, 2018; **Published:** April 04, 2018

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Abstract

To study the impact of salicylic acid on yield and yield components of maize under reduced irrigation, an experiment was conducted at Agronomy Research Farm of The University of Agriculture, Peshawar Khyber Pakhtunkhwa during summer 2015. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement having three replications. Experiment comprised of six Irrigation levels (I_0 = Zero irrigation, I_1 = One irrigation, I_2 = Two irrigations, I_3 = Three irrigations, I_4 = Four irrigations, and I_5 = Five irrigations in complete life cycle) assigned to main plots and five salicylic acid levels (SA_0 = 0, SA_1 = 150, SA_2 = 300, SA_3 = 450, and SA_4 = 600mg L^{-1}) assigned to sub plots. Results indicated that applying four irrigations resulted in more grains ear^{-1} with maximum thousand grains weight and shelling percentage of maize. Five times irrigations produced maximum grain yield and biological yield which were statistically at par with four times irrigations. Five times irrigations also produced highest harvest index. Application of 450mg L^{-1} salicylic acid produced highest grain and biological yield which were statistically similar with the application of 300mg L^{-1} of salicylic acid. It was concluded that applying four irrigations and application of salicylic acid at the rate of 300mg L^{-1} to maize resulted in higher grain yield.

Keywords: acid; Irrigations; Thousand grains weight; Biological yield; Grain yield

Introduction

Maize (*Zea mays L.*) is an important cereal crop of the world and has great economic value in livestock and poultry production [1]. It belongs to family poaceae and comes under the C_4 category of plants. It is the third mostly cultivated crop after wheat and rice all over the world as reported by Food and Agriculture Organization FAO [2] as well as in Pakistan and especially in Khyber Pakhtunkhwa (KP). It is extensively grown in temperate, subtropical and tropical regions. It can be grown on all types of soils ranging from sandy to clayey. However medium-textured soil with pH 6.5 to 7.5 is most suitable for maize.

During 2013-2014, it was cultivated on an area of 1168.5 thousand hectares with the total production of 4944.2 thousand tons and national average yield was 4231kg ha^{-1}, while in KP it was grown on about 470.9 thousand hectares with a total production of 914.8 thousand tones and average yield was 1943kg ha^{-1} [3]. Although, soil and climatic conditions of Pakistan are highly favorable for maize production and high yielding varieties are also available but yield at farmer's field is still low when compared with other maize producing countries like USA, Canada, and Egypt. In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol [4]. Generally maize needs five irrigations in its complete season in Peshawar. Due to serious water shortages the great challenge for the coming decades is the task of increasing food production with less water particularly in countries with limited water and land resources [5]. Therefore, techniques are needed to increase the water use efficiency. The increasing worldwide shortages of water and costs of irrigation are leading to an emphasis on developing techniques that minimize water use and maximize water use efficiency [6].

Salicylic acid (SA) is known as an important signal molecule for modulating plant responses to environmental stresses [7]. SA is a plant phenolic white compound and works in plant growth regulations and maintenance of certain plant hormones and enzymes. Salicylic acid can play a significant role in plant water relations Barkosky & Einhelling [8], photosynthesis, growth and stomatal regulation Arfan et al. [9] under abiotic stress conditions. Salicylic acid is also involved in endogenous signaling to trigger plant defense against pathogens [10]. Application of salicylic acid may increase stress tolerance of plants by positively altering physiological phenomena in plants. The present study was therefore conducted with aim to sort out optimum irrigation level with the application of salicylic acid under the scenario of water shortage for getting higher productivity of maize under the agro-ecological conditions of Peshawar.

Materials and Methods

The experiment was conducted at Agronomy Research Farm of The University of Agriculture Peshawar, Khyber Pakhtunkhwa during summer 2015. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement of treatments having three replications. Each replication consisted of 30 treatments with a subplot size of 3m x 2m (4 rows, 2m long). The experiment consisted of six irrigation levels (I_0 = Zero irrigation, I_1 = One irrigation, I_2 = Two irrigations, I_3 = Three irrigations, I_4 = Four irrigations, and I_5 = Five irrigations in complete life cycle) which were assigned to main plots and five salicylic acid (SA) levels (SA_0 = 0, SA_1 = 150, SA_2 = 300, SA_3 = 450, and SA4 = 600mg L^{-1}) assigned to sub plots. The irrigations were scheduled on the growth stages of maize i.e. first irrigation was given at 50% emergence, second at knee height stage, third at flowering stage (silking), fourth at ear formation and fifth at milk stage. The SA was sprayed at knee height stage. The crop was sown on 21st June, using seed rate of 30kg ha^{-1}. Row to row and plant to plant distance was kept 75cm and 20cm, respectively to get uniform plant population of maize. Azam variety of maize was sown as a test crop. Recommended dose of N: P: K at the rate of 120: 90: 60kg ha^{-1} was applied from Urea, Diammonium phosphate (DAP) and Murate of Potash (MOP) respectively. Nitrogen was applied in two equal splits i.e. 50% at sowing and 50% at second irrigation (knee height) while complete dose of P and K was applied at sowing time. All other agronomic practices were applied equally to each subplot. Data was collected on grains ear^{-1}, thousand grains weight, biological yield, grain yield, shelling percentage and harvest index.

Statistical analysis

The collected data was statistically analyzed according to analysis of variance technique recommended for RCB design with split plot arrangement. Least significant difference (LSD) test was applied to compare significant means of irrigation numbers and salicylic acid levels upon significant F-test [11].

Results and Discussion

Grains ear^{-1}

Data regarding grains ear^{-1} of maize as affected by different irrigation regimes (I) and Salicylic acid (SA) levels is reported in Table 1. Mean values of the data showed that four times irrigated plots produced highest grains ear^{-1} followed by five irrigations while lowest grains ear^{-1} were recorded for control plots (no irrigation at all). The possible reason for more grains at four irrigations might be that it fulfilled the water requirement of maize and applying further water does not help the plant to increase its grains. Application of desired quantity of irrigation water increased grains ear^{-1}. Our results are supported by Taipodia & Singh [12] and Saif et al. [13] who recorded more grains ear^{-1} at optimum level of irrigation and stated that continuous increase in irrigation water does not increase grains. Application of salicylic acid and its interaction with irrigation was found non-significant for grains ear^{-1}.

Table 1: Grains ear-1, thousand grains weight (g), biological yield (kg ha-1) and grain yield (kg ha-1) of maize as affected by application of irrigation and salicylic acid levels.

Irrigations	Grains ear^{-1}	Thousand grains weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})
I0	284d	195d	3384d	1567e
I1	320c	209c	4336c	1932d
I2	332bc	214c	4513c	1561c
I3	358b	219ab	5405b	2112b
I4	398a	233a	6298ab	2349a
I5	392a	228a	6865a	2411a
Salicylic Acid (mg L^{-1})				
0	312	204	3678d	1787c
150	336	215	4502c	1944b
300	352	215	5190ab	2258a
450	354	213	5639a	2320a
600	360	215	5075b	2193ab
LSD (0.05) for Irrigation	33.26	12.46	890.3	162.6
LSD (0.05) for Salicylic acid	ns	Ns	560.6	140.4

I_0 = zero irrigation (No irrigation at all)

I_1 = one irrigation (One irrigation given at 50% emergence)

How to cite this article: Haseeb A, Waqas L, Muhammad F J, Muhammad D A. Effect of Salicylic Acid on Yield and Yield Components of Maize under Reduced Irrigation. Agri Res & Tech: Open Access J. 2018; 15(2): 555947. DOI: 10.19080/ARTOAJ.2018.15.555947.

I_2 = two irrigations (I_1 + 2_{nd} irrigation given at knee height stage)

I_3 = three irrigations (I_1 + I_2 + 3^{rd} irrigation given at flowering stage)

I_4 = four irrigations (I_1 + I_2 + I_3 + 4^{th} irrigation given at ear formation stage)

I_5 = five irrigations (I_1 + I_2 + I_3 + I_4 + 5^{th} irrigation given at milk stage)

ns = non significant

Thousand grains weight (g)

Data regarding thousand grains weight of maize as affected by irrigation and SA levels is presented in Table 1. Irrigation had a significant however, SA and interaction of I with SA had a non significant effect on thousand grains weight of maize crop. Mean values of the data revealed that maximum 1000 grains weight was recorded in plots irrigated four times which was statistically similar to those plots which were irrigated five times. Lowest thousand grains weight was recorded in control plots. Grains required certain amount of water for its development and beyond that limit further addition of water does increased grains weight. Optimum supply of water resulted in bold and heavy grains while less water supply or water shortage resulted in small and light grains. Our results are quite in line with those of Taipodia & Singh [12] and Saif et al. [13] who reported that 1000 grains weight was profoundly affected by irrigation frequencies and heavy grains were recorded for optimum level of irrigation. Water shortage induced poor grain development and resulted in small grains with light weight [14].

Biological yield (kg ha^{-1})

Data regarding biological yield (kg ha^{-1}) of maize as affected by irrigation and SA levels is given in Table 1. Analysis of data showed that both I and SA significantly affected biomass yield of maize. Interaction of I and SA remained non significant for biological yield. Mean values showed that five times irrigated plots produced maximum biological yield which was statistically at par with biological yield recorded at four times irrigations. Minimum biological yield was recorded from control plots. Biomass yield is the weight of the whole plant and different plant parts required different amount of water which all contributes to the whole biomass yield thus applying more water will increase total biomass yield. Less water supply or water deficiency does not meet the crop water requirement thus resulted in stunted growth. Our findings are similar to Anjum et al. [15] and Saif et al. [13] who indicated highest biomass yield of maize at highest level of irrigation. Among salicylic acid levels, highest biological yield was recorded with application of 450 mg L-1 of SA which was statistically not different from 300mg L-1. Lowest biological yield was obtained in plots where no SA was applied. It may be attributed to the fact that SA enhances growth vigor of plants and increased plant growth under limited water supply. Our results are in agreement with the findings of Babar et al. [16] and Ahmad et al. [17] who reported increase in biological yield with the application of SA under limited irrigations.

Grain yield (kg ha^{-1})

Data on grain yield (kg ha^{-1}) of maize as affected by different irrigation regimes and salicylic acid levels is exhibited in Table 1. Irrigations and SA significantly while their interaction non significantly affected grain yield of maize. When averaged across SA, data showed that treatment of five times irrigation produced higher grain yield which was statistically similar with grain yield recorded at four times irrigation. Control plot produced lowest grain yield. It might be due to the influence of irrigation water at proper time which increased growth and development and also produced higher grains ear^{-1} and 1000 grains weight which ultimately increased yield of maize. Anjum et al. [15] reported that application of irrigation at proper stage increased yield and yield components of maize. Optimum and timely availability of water enhances nutrients uptake, help the plant to grow properly and led to higher grain yield [13]. Among salicylic acid levels, highest grain yield was recorded with application of 450mg L-1 SA which was statistically at par with the application of 300 mg L-1. Lowest grain yield was recorded from control plots. As SA plays a role in plant water relations, enhances photosynthesis and growth which thus contribute in the final grain yield. Our results are in agreement with Ahmad et al. [17] and Zamaninejad et al. [18] who described that salicylic acid increased grain yield of maize.

Shelling percentage

Irrigations had a significant while salicylic acid had a non significant effect on shelling percentage of maize (Table 2). Highest shelling percentage was recorded from the treatment of five times irrigations which was statistically at par with the treatment of four times irrigations while minimum shelling percentage was recorded from control. Increase in shelling percentage with increase in irrigation levels might be due to increase in grains weight ear^{-1} and 1000 grains weight. Lower grain weight under reduced irrigation might be the reason for lower shelling percentage. Our results are in line with Hussain et al. [19] who reported maximum shelling percentage for different irrigation frequencies. Aguilar et al. [14] Proved that increase in irrigation levels increased shelling percentage and with decrease in irrigation shelling percentage decreased accordingly. Interaction of treatments i.e. irrigation and salicylic acid was found non significant for shelling percentage.

Harvest index (%)

Data on harvest index of maize as affected by irrigation and SA levels is shown in Table 2. Analysis of the data showed that

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irrigations had a significant while SA had a non significant effect on harvest index of maize. SA and I interaction was also found non significant. Means showed that maximum harvest index was recorded from the treatment of five times irrigations followed by four irrigations while minimum value of harvest index was recorded for control treatment. Greater difference between grain and biological yield at reduced irrigation might be the reason for lower harvest index. Our results are in line with Wajid [20] who stated that harvest index was affected significantly by irrigation frequencies.

Table 2: Shelling Percentage (%) and Harvest Index (%) of maize as affected by application of irrigation and salicylic acid levels.

Irrigations	Shelling Percentage (%)	Harvest Index (%)
I0	68d	21d
I1	73bc	24c
I2	73bc	25c
I3	75b	27bc
I4	78a	28b
I5	79a	31a
Salicylic Acid (mg L-1)		
0	74	26
150	74	26
300	76	27
450	75	28
600	76	28
LSD (0.05) for Irrigation	2.98	2.54
LSD (0.05) for Salicylic acid	ns	ns

Conclusion

It can be concluded from the study that treatment of five times irrigations produced maximum grain yield which was statistically similar with treatment of four times irrigations. Among Salicylic acid levels, application of 450mg L-1 SA produced highest grain and biological yield which was statistically similar with the application of 300mg L-1. Thus, irrigating field four times and application of 300mg L-1 SA is recommended for obtaining higher maize yield under the agro-climatic conditions of Peshawar region.

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