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Evaluation of NPK Levels and Irrigation Scheduling to Improve Water Productivity of in Drip Irrigated Maize

Haseeb Ahsan, Muhammad Manzoor, Malik Muhammad Akram, Mujahid Ali, Habibullah Habib, Muhammad Mohsan, Tahir Mehmood, Ammar Ahmad, Habib ur Rehman and Hafiz Muhammad Bilal

On Farm Water Management, Punjab, Pakistan

Abstract: Under changing climatic conditions, soil moisture measuring technologies are vital for irrigation scheduling. In the laser-leveled field, a field experiment was designed on hybrid maize DK-6317 under drip irrigation during Spring 2022. The seeds were sown on beds with maize planter. Four treatments i.e., 75% of the recommended dose of NPK + Irrigation at 15% soil moisture deficit, 75% recommended dose of NPK + Irrigation at 30% soil moisture deficit, 50% recommended dose of NPK + Irrigation at 15% soil moisture deficit, 50% recommended dose of NPK + Irrigation at 30% soil moisture deficit were executed. The experiment was replicated three times and the layout was designed on RCBD. It was observed that the water productivity (WP) of 75% of the recommended dose of NPK + Irrigation at 15% soil moisture deficit was 1.63 Kg/m^3 which was 17% more as compared with 50% recommended dose of NPK + Irrigation at 30% soil moisture deficit (1.39 Kg/m^3). While 75% recommended dose of NPK + Irrigation at 30% soil moisture deficit showed WP of 1.79 Kg/m^3 which had a maximum impact of 28% more as compared with 50% recommended dose of NPK + Irrigation at 30% soil moisture deficit (1.39 Kg/m^3). In another treatment, 50% recommended dose of NPK + Irrigation at 15% soil moisture deficit expressed WP of 1.58 Kg/m^3 which was 13% more than 50% recommended dose of NPK + Irrigation at 30% soil moisture deficit (1.39 Kg/m^3).

Key words: Maize · Water Productivity · Yield · Soil Moisture Deficit Levels · Maximum Allowable Depletions

INTRODUCTION

During 2021-22, maize crop was sown on an area of 1,653 thousand hectares and recorded an increase of 16.6 percent over last year's cultivated area of 1,418 thousand hectares. Maize crop output was recorded at 10.635 million tons witnessing significant growth of 19.0 percent over 8.940 million tons last year maize contributes 3.2% added in agriculture and 0.7% to GDP. The increase in production was mainly due to increased sown area, availability of improved high-yield seed varieties, favorable weather conditions and better economic returns [1].

Water scarcity has become a burning issue in the country [2]. Pakistan had an abundance of water, with more than 1600 m^3 of water per capita during 1947. Pakistan may soon be among the countries with limited water supplies (those with fewer than 1000 m^3 of water per capita). The Indus River system and its tributaries, primarily fueled by snow and glacier melt in the larger Himalayas, are the only water sources for the nation. Pakistan, which has a per capita water availability of 1017 m^3, is the third most susceptible country in terms of the water problem, according to the International Monetary Fund [3]. According to GDP, Pakistan is ranked first in terms of water consumption. Water is the primary input for agriculture, yet there are growing problems with irrigated agriculture, such as insufficient water availability for crop productivity and ineffective irrigation for crop production, poor irrigation efficiency and low water productivity is mostly hampered by over- or under-irrigation [4]. Pakistan will experience a severe water crisis by 2025 [5].

Correspondents Author: Mujahid Ali, Water Management Research Farm, 56150 Renala Khurd, Okara, Punjab, Pakistan. Tel: +92-300-2573000.

In Pakistan, agriculture is a key factor in economic growth. Since it uses around 95% of the available water resources, water is what it depends on most. Punjab is Pakistan's agricultural and economic center, providing roughly 80% of the nation's food needs through the production of rice, 70% of wheat, 80% of cotton and nearly 60% of sugarcane. Punjab is home to more than 70% of Pakistan's arable land, while more than 90% of the province's agricultural output comes from irrigated lands. Due to the region's predominately arid and semi-arid climate, the Indus Basin Irrigation System, one of the world's biggest contiguous gravity flow networks, is used to irrigate more than 80% of the farmed land Indus Basin Irrigation System (IBIS).

Water productivity (WP) is a robust benchmark for crop production in relation to the available water supply across spatial scales. Determining the water productivity of maize is of vital importance. The objective of the research was to assess the water productivity of hybrid maize crops using different fertilizer levels and mad levels under a drip irrigation system [6]. Enhancement of water productivity in maize crop is vital to meet food security [7]. Previously improvement was recorded in the water productivity of sunflower crop [8]. Water productivity in high-altitude areas of the United States was also observed [9]. Various methods were adopted to measure water productivity in agronomic crops [10].

According to 2018, National Water Policy, more than 50% of canal water diverted from the Indus system does not get to the agricultural level. So, 1 million tube wells, extracting roughly 55 MAF, provide nearly 20% of agricultural demands [11]. Therefore, the nation's agriculture, which generates roughly 24% of the GDP and provides 42.3% of sources of income for subsistence [12], is in danger. While over 90% of water is used for agriculture [13] and over 80% of it is used simply for agriculture by wheat, cotton, maize, sugarcane and rice. Pakistan has major crops which need water in abundance. ¾ area of the country has less than 250 mm of annual rainfall. 70% of our rain is during monsoon (July-August). Rivers are the major source of water followed by rainfall [14].

About 60% of the area commanded by the Indus Basin Irrigation System (IBIS) is in the Punjab i.e., 8.4 million hectares (21 million acres) served through about 58,500 outlets. Punjab’s agro-based economy is led by irrigated agriculture, which accounts for around 28% of the GDP and employs more than 50% of the workforce. Two-thirds of the people live in rural areas and depend on this industry either directly or indirectly for their livelihood. Despite irrigated agriculture's vital importance to national and provincial growth, it was unable to function sustainably, mostly because irrigation operations were not modernized, resulting in enormous water loss from outdated, ineffective irrigation techniques [15].

MATERIALS AND METHODS

An experiment was designed at Water Management Research Farm, Renala Khurd, Okara (Fig 1). Before sowing the crop, the soil was analyzed to prepare the fertigation schedule per soil nutrient status. After land preparation, DAP and SOP @ 1 bag (50 kg each) were applied per acre as basal dose. A maize hybrid (DK6317) was sown with four treatments i.e., 75% recommended dose of NPK + 15% water depletion/MAD levels, 75% recommended dose of NPK + 30% water depletion/MAD levels, 50% recommended dose of NPK + 15% water depletion /MAD levels, 50% recommended dose of NPK + 30% water depletion /MAD levels. The seed of the maize hybrid was sown o beds with maize planters. The experiment was designed on RCBD with three replicates. Data regarding agronomic traits i.e., plant height (cm), cob height above ground (cm), cob length (cm), plot size (m^2), plant population, plants per line. Data regarding the number of beds, biomass above ground (kg/m^2), biomass below ground (kg/m^2), biomass above ground (kg/Acre) and biomass below ground (kg/acre).

To ensure proper irrigation management, the CropWat model was used to calculate the amount of water to be applied to the crop. The field layout was designed as per RCBD for statistical analysis of the data. Statistics version 10 was used for the analysis of data.

Table 1: Agronomic attributes of maize (DK-6317) grown under various water deficit levels

Treatment	Plot Size (m2)	Water applied in each plot (m^3)	Plant Population/plot	Plants per bed	Number of beds
75% NPK + Irrigation at 15% soil moisture depletion levels	1011	1564	9588	188	51
75% NPK + Irrigation at 30% soil moisture depletion levels	1011	1564	9588	188	51
50% NPK + Irrigation at 15% soil moisture depletion levels	1011	1564	9588	188	51
50% NPK + Irrigation at 30% soil moisture depletion levels	1011	1564	9588	188	51

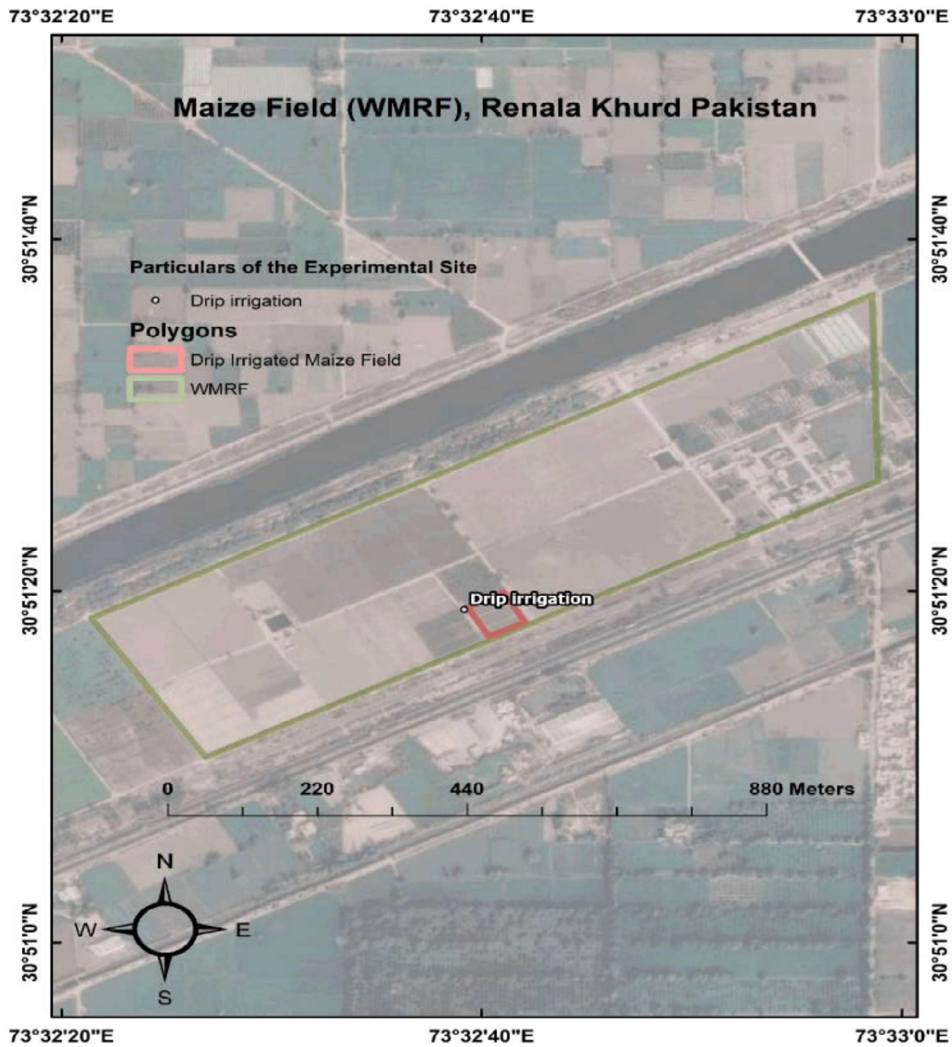

Fig. 1: Location of maize field of water management research farm, Renala Khurd, Okara, Punjab-Pakistan

RESULTS

The above results showed 50% recommended dose of NPK (50% NPK) + Irrigation at 15% soil moisture deficit (15% SMD) resulted in a maximum plant height of 241 cm. Seventy five (75) % recommended dose of NPK (75% NPK) + Irrigation at 15% SMD resulted in a minimum plant height of 231 cm which was at par with 75% NPK + Irrigation at 30% SMD. 50% NPK + Irrigation at 30% SMD resulted in maximum plant height value of 238 cm (Fig 2).

The above results showed 50% NPK + Irrigation at 15% SMD resulted in a maximum cob height from the ground is 128 cm. 75% NPK + Irrigation at 15% SMD resulted in a minimum cob height from the ground of 120 cm. 75% NPK + Irrigation at 30% SMD resulted showed cob height from the ground with an average value of 124 cm. 50% NPK + Irrigation at 30% SMD resulted in cob height from the ground average value of 126 cm (Fig 3). It was observed that 75% NPK + Irrigation at 15% SMD resulted in a minimum cob length of 29 cm, while all other treatments showed a cob length average value of 126 cm (Fig 4).

75% NPK + Irrigation at 15% SMD produced a grain yield of 6918 tons/ha, however, 75% NPK + Irrigation at 30% SMD produced a maximum grain yield of 7413 tons/ha, 50% NPK + Irrigation at 15% SMD produced grain yield of 6721 tons/ha, while 50% NPK + Irrigation at 30% SMD produced minimum grain yield of 5930 tons/ha. It was observed that the water productivity of 75% NPK + 15% SMD was 1.63 Kg/m^3 which was 17% more as compared with 50% NPK + Irrigation at 30% SMD (1.39 Kg/m^3). While 75% NPK + Irrigation 30% SMD was

Table 2: Water productivity and impact of yield and water productivity

	Result/Outcomes		
Treatments	Water applied (m^3/ha)	Yield (Kg/ha)	WP (Kg/m^3)
75% NPK + Irrigation at 15% soil moisture deficit	4253	6918	1.63 (1.39)
Impact: +17%			
75% NPK + Irrigation at 30% soil moisture deficit	4253	7413	1.79 (1.39)
Impact: +28%			
50% NPK + Irrigation at 15% soil moisture deficit	4253	6721	1.58 (1.39)
Impact: +13%			
50% NPK + Irrigation at 30% soil moisture deficit	4253	5930	1.39

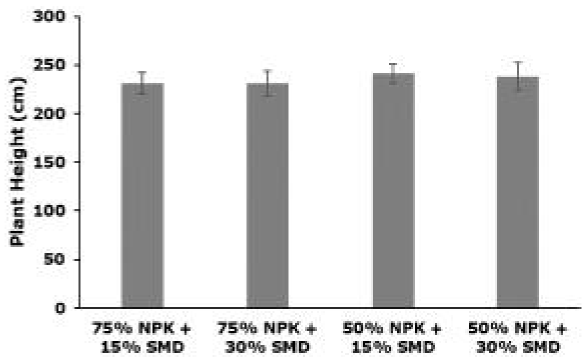

Fig. 2: The height of maize is influenced by different water depletion levels and NPK doses

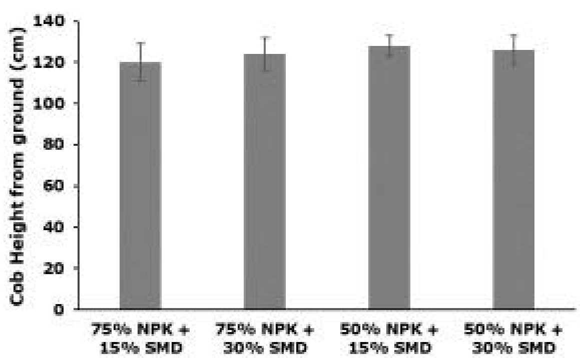

Fig. 3: The cob height of maize from the ground influenced by different water depletion levels and NPK doses

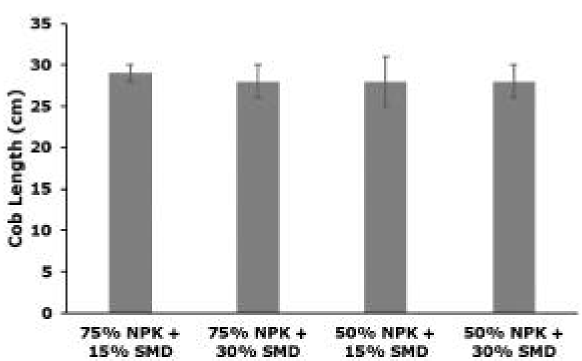

Fig. 4: The cob length of maize influenced by different water depletion levels and NPK doses

1.79 Kg/m^3 which had a maximum impact of 28% more compared with 50% NPK + Irrigation at 30% SMD (1.39 Kg/m^3). 50% NPK + Irrigation at 15% SMD had 1.58 Kg/m^3 which was 13% more than 50% NPK + Irrigation at 30% SMD (1.39 Kg/m^3) (Table 2).

DISCUSSION

Grain yield in maize is influenced by ears/unit area, number of kernels/ear (comprising number of kernel/rows and kernels/row) and weight of kernel. Every of these yield constituents is noted at dissimilar phases in the lifecycle of the plant. Adequate water and nutrients are necessary for satisfactory canopy size and ampule yield. The initial reproductive structures' numeral is often superior to what the plant is later proficient in supporting. The size of yield components is then influenced by the environmental and management stresses of the growing season [16]. The present research was executed to probe the crop water productivity of maize hybrid under different water depletion levels. Controlled deficit irrigation arrangement rehearsal is the method of dropping the quantity of water applied/irrigation at certain crop growth phases with the purpose of saving water and energy under prevailing energy crises. Results revealed 75% NPK + 15% deficit Irrigation produced grain yield of 6918 tons/ha, 75% NPK + 30% deficit irrigation produced maximum grain yield of 7413 tons/ha, 50% NPK + 15% deficit irrigation produced grain yield of 6721 tons/ha, while 50% NPK + 30% deficit irrigation produced minimum grain yield of 5930 tons/ha.

The results of crop water productivity in the present research work were supported by HY *et al.* [17] who recorded water productivity as 2.11-3.37 kg m^{-3}. Lai *et al.* [18] WUE recorded WUE (3.42 kg m^{-3}) for the QS51 maize hybrid, the value was close to our findings of WUE (3.16 Kg/m^3). A slight difference in the values might be due to different geographical conditions, types of soil and maize hybrids. Dumet-Montoya *et al.* [19] recorded water productivity of maize ranged from 1.84 to 2.79 kg m^{-3} in

Azul, Argentina. Other researchers like Roygard [20], Szalokine [21], Jin *et al.* [22] and Victor *et al.* [23] observed 2.34-2.88 kg m^{-3} at Fundulea, Romania, 1.28-2.44 kg m^{-3} at Szarvas, 1.49-2.67 kg m^{-3} at Wangtong and 1.26-2.31 kg m^{-3} at Xifeng, respectively. The water productivity of 75% NPK + 15% deficit Irrigation was 1.63 Kg/m^3 having impact of +17% as compared with 50% NPK + 30% deficit irrigation (1.39 Kg/m^3). While, 75% NPK + 30% deficit irrigation was 1.79 which had maximum impact of +28% compared with 50% NPK + 30% deficit irrigation (1.39 Kg/m^3). 50% NPK + 15% deficit irrigation had 1.58 which had +13% impacts than 50% NPK + 30% deficit irrigation (1.39 Kg/m^3). Our findings were in line with Chauhdary *et al.* [24] who executed research work on maize under drip irrigation and recorded water irrigation water saving of up to 48% close to our research work. Oiganji *et al.* [25] executed research work on maize crops under drip irrigation using different depletion levels and noted crop water productivity of maize crop ranged 0.41-1.98 kg/m^3 lower than our research work. This might be due to variations in edaphic and varietal features in both studies.

The above results showed 50% recommended dose of NPK + 15% deficit irrigation resulted in a maximum cob height from the ground is 128 cm. 75% recommended dose of NPK + 15% deficit irrigation resulted in a minimum cob height from the ground of 120 cm. 75% recommended dose of NPK + 30% deficit irrigation resulted showed cob height from the ground with an average value of 124 cm. 50% recommended dose of NPK + 30% deficit irrigation resulted in cob height from the ground average value of 126 cm. 75% recommended dose of NPK + 15% deficit irrigation resulted in a minimum cob length of 29 cm while all other treatments showed a cob length average value of 126 cm. The results were supported by El-Labad *et al.* [26] who recorded unmarketable tomato yield with a water depletion irrigation level of 60% whereas the lowermost values were documented with depletion levels of 80 and 100% same trend was recorded in our research. Soil physical properties and tillage methods also impact as was observed by Rashidi *et al*. [27] and Abd-Elmonsef and Abd El-Lateef [28] in watermelon. So under water deficit conditions management strategies are required [29]. Drip irrigation is one of the most vital strategies in this regard [30] which positively influences moisture deficiencies made by evapotranspiration [31].

CONCLUSION

It was concluded that 75% recommended dose of NPK + Irrigation at 30% soil moisture deficit expressed the highest yield and water productivity, while it was lowest in 50% recommended dose of NPK + Irrigation at 30% soil moisture deficit.

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