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Characteristic of soil moisture utilisation with different water-sensitive cultivars of summer maize in the North China Plain

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Abstract: Summer maize cultivars are differently sensitive to soil moisture. To better understand the differences in water productivity of summer maize cultivars with different water sensitivity, a field experiment was conducted from 2020 to 2022. Three different water-sensitive summer maize cultivars were selected, including TY808 (high water-sensitive cultivar), DH605 (medium water-sensitive cultivar), and ZD958 (low water-sensitive cultivar). Soil water content (SWC), soil water storage (SWS), water consumption, water use efficiency, and grain yield were determined. The results showed that under rainfed conditions, the SWC of the medium water-sensitive cultivar DH605 in the deep soil layer was 2.1–18.2% lower than TY808 and ZD958, respectively, and the differences were significant in the 12th leaf stage (V12) and vegetative tassel stage (VT). The SWS of the high-water-sensitive cultivar TY808 was 0.7% to 6.4% higher than the other two water-sensitive cultivars from 2020 to 2022. The changes in SWS are related to the spatiotemporal distribution of precipitation. The water consumption of DH605 was higher than TY808 and ZD958 by 5.3% and 7.09% in 2020 and 2.9% and 2.8% in 2021; in 2022, DH605 is 2% higher than ZD958 and 2.8% lower than TY808, respectively. The yield of DH605 was 4.3–10.78% higher than the other two cultivars in the three-year experiment. Additionally, the 1 000-kernel weight of DH605 was the highest in TY808 and ZD958. DH605 has the highest water use efficiency, which was increased by 4.8–14.6% compared to TY808 and ZD958. Through path analysis, we found that the direct path coefficient of SWS in the VT stage on yield reached 0.999, indicating that soil moisture in the VT stage has the greatest impact on yield, followed by the blister stage (R2). In conclusion, our results suggest that the water consumption of summer maize during the VT stage is the highest, and the soil moisture condition in VT significantly affects the grain yield of summer. Planting DH605 in the North China Plain would harvest the maximum grain yield and water productivity.

Keywords: rainfed agriculture; extreme weather events; *Zea mays* L.; variety selection; high water-efficient agriculture

Soil moisture is the most crucial factor influencing crop growth. However, the shortage of soil water storage causes the reduction of yield, referred to as crop water stress (Omondi et al. 2021). Rainwater is the primary source of soil moisture, especially under rainfed agricultures (Jaramillo et al. 2020), but the frequency and intensity of extreme weather events, such as prolonged droughts and heavy rainfall, are expected to increase (Chen et al. 2020, Tang et al. 2021), which increase water loss through evaporation and runoff. Insufficient precipitation during critical growth stages is not adequate for crop water demands and biomass production (Huang et al. 2021); conversely, too much rainwater during the rainy season intensifies the problems of crop lodging and soil erosion (Routschek et al. 2014) and further jeopardised agricultural output (Malhi et al. 2021). Therefore, effective field crop management for cli-

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mate change has a serious impact on agricultural production security (Ramesh et al. 2019).

The North China Plain (NCP) is of great significance to summer maize agriculture production (Xu et al. 2022). In the past decades, the total annual grain output of the North China Plain has accounted for about 23% of the total national grain output (Yang et al. 2022). The region has abundant groundwater resources, but due to long-term unreasonable excessive extraction and inappropriate agricultural water management, issues such as declining groundwater and reducing surface water sources are becoming increasingly prominent (Yin et al. 2021). Nevertheless, the growing season of summer maize in the NCP has witnessed a rising occurrence of extreme rainfall events, including typhoons and heavy downpours. It is urgent to enhance the efficient utilisation of rainwater with the status of water deficit (Ma et al. 2021, Yu et al. 2021).

The drought or elevated soil moisture state adversely affects summer maize's growth and development (Rigano et al. 2016, Chen et al. 2017). For example, Du et al. (2021) found that during the early stage of summer maize, excessive soil moisture resulted in inadequate root development and oxygen deficiency in the root zone, impeding growth and reducing yield potential. Liu et al. (2022) found that in the reproduction stage of maize, excessive soil moisture adversely affected crop pollination (Liu et al. 2022). Elevated precipitation resulted in the waterlogging of the flowering stage of summer maize, thereby impeding the successful transportation of pollen grains to the stigma, posing a challenge for the fertilisation process and reducing grain formation (Yang et al. 2019). Moreover, during the crucial growth stage, excessive soil moisture increased the risk of disease occurrence, which was detrimental to the crop's kernel development and grain quality. Under drought conditions, plants with high water sensitivity are more responsive to water availability, and drought affects them more significantly than plants with medium and low water sensitivity (Ashrafi et al. 2018). Most of the water sensitivity and drought resistance studies focused on investigating different irrigation levels within the same cultivar. However, the research on the response of different water-sensitive cultivars under rain-fed conditions is still limited.

In this study, the dynamic changes in soil moisture and the water consumption of summer maize crops were investigated under rain-fed conditions. Three different water-sensitivity cultivars of summer maize were selected for the experiment, including TY808 (high water sensitivity cultivar), DH605 (moderate water sensitivity cultivar), and ZD958 (low water sensitivity cultivar). We hypothesised that the medium or high-water-sensitive cultivars may absorb more soil water under rain-fed conditions, resulting in higher yield and water use efficiency (WUE). The objectives of the experiment were to (1) investigate the dynamic changes in soil moisture and water consumption of summer maize crops under rain-fed conditions; (2) examine the differences in soil moisture utilisation among different water sensitivity cultivars of summer maize in the region; and (3) explore the relationship between water use efficiency and grain yield of summer maize for different water-sensitive cultivars. This study evaluated the water use characteristics of summer maize with different cultivars and would provide improved strategies for cultivar selection of high water-efficient agriculture in the NCP.

MATERIAL AND METHODS

Experimental site. The field experiment was conducted at the Experimental Station of Shandong Agricultural University at 36°10'9"N, 117°9'03"E in the NCP from 2020 to 2022. The area belongs to a warm temperate continental semi-humid climate zone and is characterised by hot and rainy summers. Due to the influence of the monsoon climate, there are significant inter-annual differences in rainfall in this region. During the summer maize planting period, the daily average air temperature ranged from 24.59 to 25.69 °C, and the rainfall was 806, 691, and 574.56 mm in 2020, 2021, and 2022, respectively (Figure 1).

Experimental design. The experiment was conducted in experimental pools (3 m × 3 m × 1.5 m, length × width × depth), and cement boards surrounded the pools to prevent lateral movement of soil moisture. A 1.2-m neutron probe is buried in the centre of each pool. The soil texture at the experimental site is loam, with a composition of 40% sand, 44% silt, and 16% clay. In the 0–20 cm soil layer, the total nitrogen, available phosphorus, and available potassium contents were 108.3, 16.2, and 92.6 mg/kg, respectively. The organic carbon content in the 0–20 cm soil layer was 14 g/kg. At 0–120 cm, the average field capacity is 35.05%, the average volume weight is 1.50 g/cm^3, the average wilting moisture is 7.65 *v*/*v* %, and the average available water is 36.15 mm. Three different water-sensitivity summer maize cultivars were used in the experiment, i.e., high water sensitivity cultivar (Tunyu 808, TY808), moderate water

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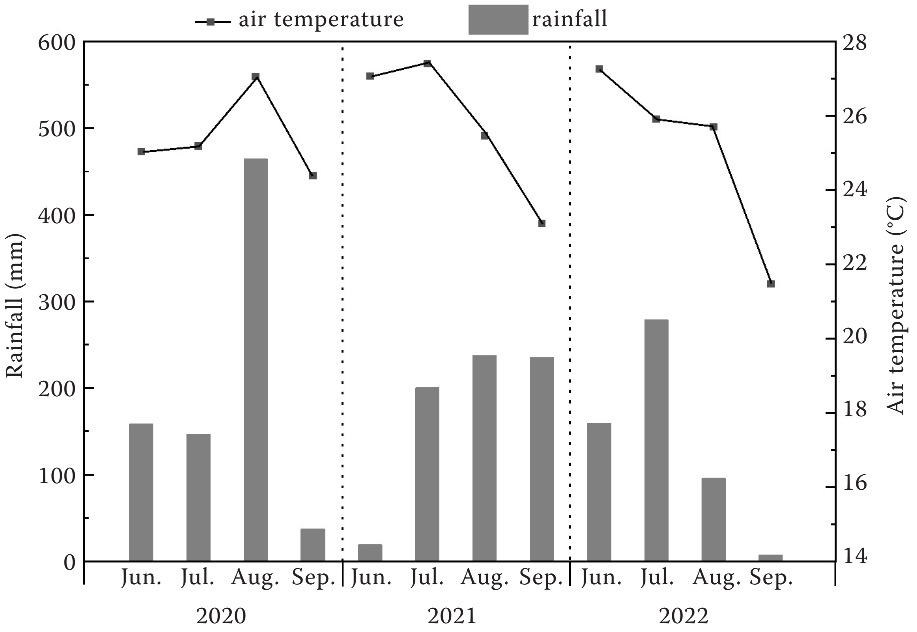

Figure 1. The monthly rainfall and air temperature during the growth period of summer maize from 2020 to 2022. The meteorological data in June was recorded after sowing, and the record was ended until harvest in September

sensitivity cultivar (Denghai 605, DH605), and low water sensitivity cultivar (Zhengdan 958, ZD958). Every treatment was repeated three times, and a total of nine plots were arranged with a randomised block design. The planting density was 6.11 plants/m^2 with a seed row spacing of 60 cm and a plant spacing of 28 cm. The plants were sowed on June 9th, June 20th, and June 19th in 2020, 2021, and 2022, respectively, and harvested on September 14th, September 24th, and September 24th in the same year. Before sowing, $CO(NH_2)_2$ (22.5 g/m^2), KCL (16.9 g/m^2), and $(NH_4)_2HPO_4$ (22.5 g/m^2) were applied as basic fertiliser. Additional N (22.5 g/m^2) was applied during the vegetative tassel (VT) phase, with a ratio of 1:1 between the sowing and VT stage.

Soil volumetric water content. CNC503DR intelligent neutron moisture meter (supplied by Beijing Soupcon Nuclear Technology Co. Ltd., Beijing, China) was used to measure soil moisture. The measurement range was from 0 to 120 cm depth with an interval of 10 cm. Soil water content (SWC) was measured every 10 days during the entire growth period of summer maize. Additional measurements were conducted before and after heavy rainfall events. To ensure the accuracy of soil water measurements, every CNC503DR sensor was tested and calibrated before installation.

Soil water storage. The variation of soil water storage (SWS) within a depth of 0–120 cm was investigated, as the main root system of summer maize is distributed in the soil layer of 0–100 cm (Zhang et al. 2022). SWS was calculated using the following formula:

$$SWS = \Sigma(\Delta\theta_i \times Z_i) \quad (1)$$

where: $\Delta\theta_i$ – SWC (%) at a certain soil layer; Z_i – the thickness (mm) of that soil layer; i – soil layer number (1, 2, 3, ..., 12).

Crop water consumption. Crop water consumption (ET) was calculated based on the soil water balance equation (Ren et al. 2018):

$$ET = I + P - R - D + \Delta S \quad (2)$$

where: I – irrigation amount during the growth period of summer maize, with no artificial irrigation during the growth period; P – rainfall amount during the growth period of summer maize (mm); R – surface runoff (mm), which was not observed during the growth period of summer maize as there was no drainage problem since the water level of the water reservoir was 15 cm higher than the ground surface; D – deep seepage (mm), which was calculated as the effective SWC (mm) in the 120 cm soil layer before rainfall + rainfall amount (mm) – field water holding capacity (mm) (Ertek et al. 2006); ΔS – variation of SWS measured before sowing and at harvest time within the 0–120 cm soil layer (mm).

Yield and yield components. During the harvest of summer maize, the effective number of ears per plot was investigated, and all summer maize in each plot was manually harvested. After air drying, the number of rows and grains per ear were counted, and the total grain yield and thousand-grain weight were measured.

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WUE is calculated as follows:

$$WUE = Y / ET \quad (3)$$

where: Y – kernel yield of summer maize (kg/m^2); ET – total water consumption during the growth period of summer maize (mm).

Statistical analysis. Statistical analysis was conducted using IBM SPSS Statistics 26 (IBM, Chicago, USA). An ANOVA was performed to assess treatment differences, with statistical significance set at $P \leq 0.05$, determined by the least significant difference (*LSD*) test. Microsoft Excel 2010 (Redmond, USA) was utilised for data organisation and analysis.

RESULTS

Soil water content. The distribution of SWC in soil profiles was influenced by summer maize cultivars (Figure 2). During the V12 stage, the vertical profiles of SWC were similar for three summer maize cultivars in the same year. No significant differences appeared among treatments in the 0–80 cm soil layer. However, in the 80–120 cm soil layer, TY808 and ZD958 had higher SWC values than DH605. At the R2 stage, in the 0–80 cm soil layer, the SWS of all cultivars generally shows an increasing trend with the increase of soil depth; SWC at the deep

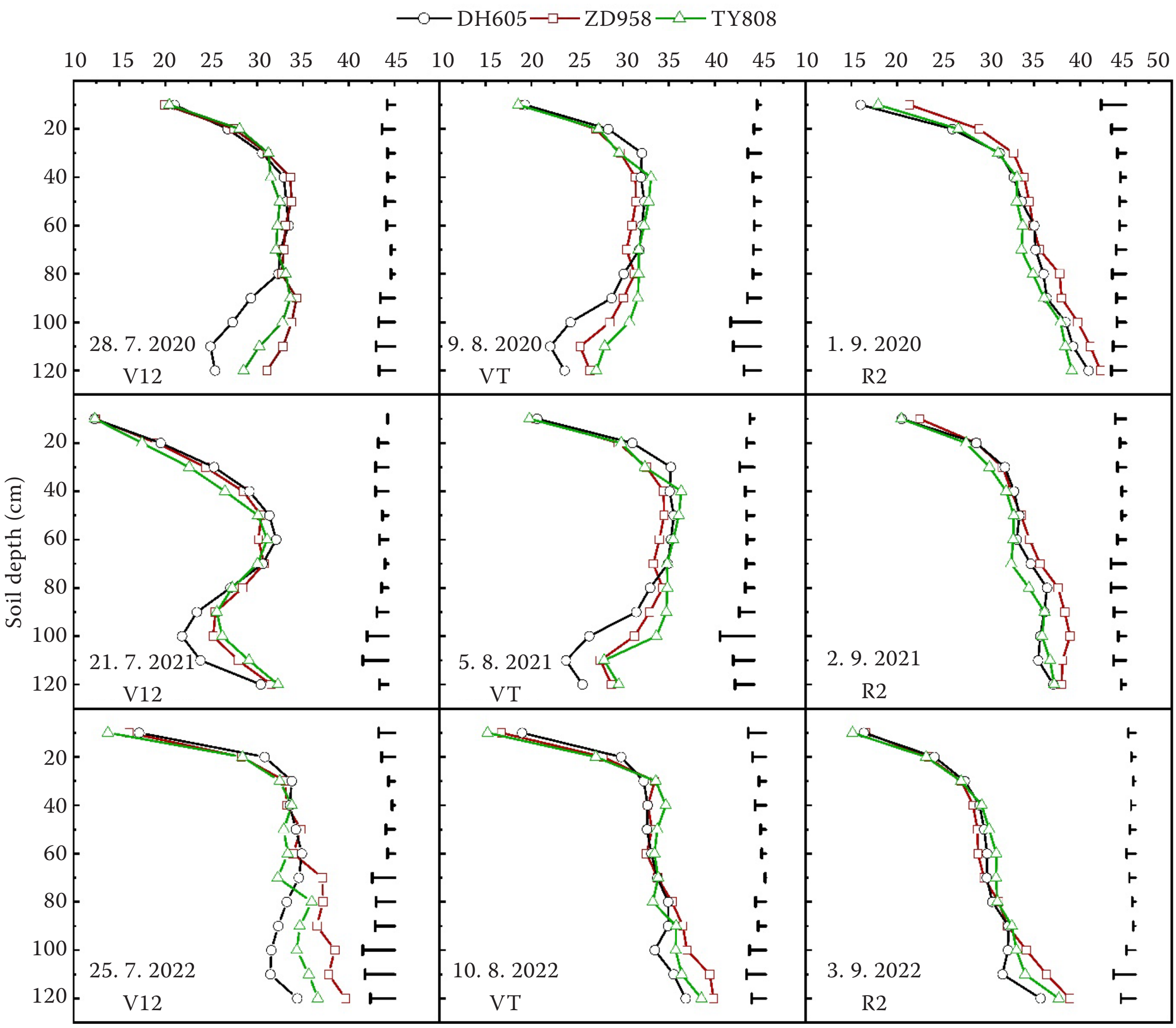

Figure 2. The variation of soil water content (SWC) in 0–120 cm soil layers during the V12, VT and R2 stages in 2020, 2021 and 2022 summer maize growing seasons. The horizontal line represents the maximum error of SWC for three different cultivars of summer maize at the same soil depth. Different growth seasons of summer maize: V12 – 12th leaf stage; VT – vegetative tassel stage; R2 – blister stage

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soil layer is significantly lower in DH605 compared to the other two cultivars. Compared to TY808 and ZD958, SWC of DH605 showed an average reduction (0–120 cm) of 11.97% and 15% (in 2020), 8.2% and 9.4% (in 2021), and 11.1% and 6.3% (in 2022) in SWC during the V12 stage, and 9.0% and 13.6% (in 2020), 9.0% and 12.3% (in 2021), and 6.1% and 2.0% (in 2022) during the VT stage, respectively. In deep soil layers (80–120 cm), DH605 is 13.3% and 18.2% lower than TY808 and ZD958 (in 2020), 9% and 10.4% (in 2021), 12.5% and 6.7% (in 2022) in deep SWC during the V12 stage, and 9.8% and 15.7% (in 2020), 9.6% and 16.1% (in 2021), 6.5% and 2.1% (in 2022) in deep SWC during the VT stage.

Soil water storage. The SWS were significantly affected by summer maize cultivars (Figure 3). As the significant interannual differences in rainfall (Figure 1), the SWS was hugely affected by rainfall events. Overall, TY808 exhibited greater SWS compared to the other two cultivars. At the VT stage, the SWS of TY808 was 3.6% and 1.8% higher than that of DH605 and ZD958 in 2021 and 3.8% and 2.2% in 2022, respectively. Similarly, during the R2 stage from 2020 to 2022, SWS in TY808 was 5.1% and 6.38% higher than that in DH605 and ZD958 in 2020, 3.6% and 5.5% in 2021, and 3.2% and 0.7% in 2022, respectively.

Additionally, the SWS of DH605 was generally lower than that of TY808 and DH605. In 2020, the SWS of DH605 was 4.26% and 6.5% lower than that of TY808 and DH605 in the V12 stage and 12.6% and 8% in the physiological maturity stage (R6), respectively. In 2021, the SWS of DH605 was 3.6% and 3.5% lower than TY808 in the R2 and R6 stages and 1.8% and 1.3% higher than ZD958 in the same period, respectively. In 2022, the SWS of DH605 was 3.8% and 3.2% lower compared to TY808 and ZD958 in the VT stage, respectively, and 2.6% and 2.4% lower in the R2 stage, respectively.

Water consumption. During the first and second growing seasons, there are significant differences in water consumption between DH605 and the other two cultivars (Table 1). The water consumption of DH605 was higher than that of TY808 and ZD958 by 5.3% and 7.09% in 2020, respectively, and by 2.9% and 2.8% in 2021, respectively. However, in the third growing season, TY808 had the highest water consumption, which was 2.8% and 4.8% higher than DH605 and ZD958, respectively. As for the stage water consumption of summer maize, the vegetative and emergence stage (VE) – 6th leaf stage (V6) exhibited the lowest water consumption and the V6–VT stage had the highest water consumption. As the plants entered the R2–R6 stage, there was a noticeable decline in water consumption.

In 2020, the water consumption of DH605 was higher than TY808 and ZD958 by 9.3% and 17.2% (VT–R2), 5.4% and 7.1% (R2–R6), respectively. In the VT–R6 stage of 2022, the water consumption of DH605 decreased by 1.5% and 21.2% (VT–R2), 30.7% and 16.7% (R2–R6) compared to TY808 and ZD958.

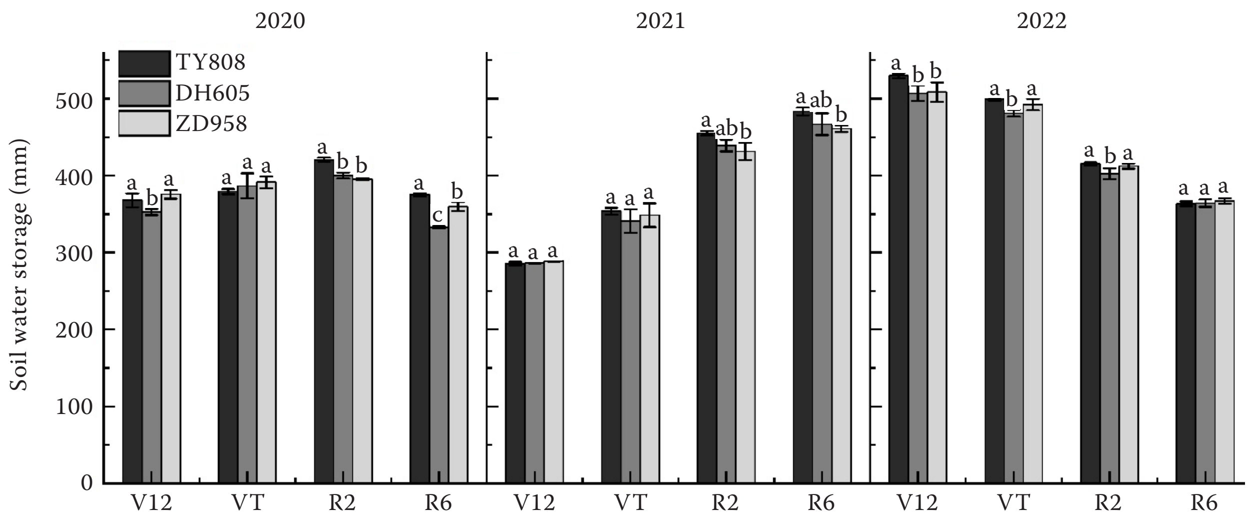

Figure 3. Soil water storage of different water-sensitive cultivars of summer maize at different growth stages in 2020, 2021 and 2022. The vertical bars indicate the standard errors. In each growing season, values followed by different letters are significantly ($P < 0.05$) different among treatments. Different growth seasons of summer maize: V12 – 12th leaf stage; VT – vegetative tassel stage; R2 – blister stage; R6 – physiological maturity stage

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Table 1. Stage water consumption and total water consumption in 2020, 2021 and 2022 summer maize growing seasons

Treatment		VE–V6	V6–VT	VT–R2	R2–R6	Total water consumption
	TY808	33.89^{b}	110.63^{b}	133.35^{b}	49.82^{b}	327.69^{b}
2020	DH605	46.84^{a}	96.94^{b}	147.06^{a}	55.54^{a}	346.38^{a}
	ZD958	44.85^{a}	112.05^{a}	121.73^{b}	43.17^{b}	321.80^{b}
	TY808	76.96^{a}	115.66^{b}	85.85^{b}	78.69^{a}	357.16^{b}
2021	DH605	76.40^{a}	122.83^{a}	89.25^{b}	79.38^{a}	367.86^{a}
	ZD958	79.56^{a}	97.63^{c}	104.53^{a}	77.38^{a}	359.10^{b}
	TY808	30.67^{b}	177.90^{b}	102.21^{b}	58.30^{a}	369.08^{a}
2022	DH605	33.32^{a}	180.11^{a}	100.66^{c}	44.59^{c}	358.73^{b}
	ZD958	21.21^{c}	156.04^{c}	121.99^{a}	52.05^{b}	351.29^{c}

Different growth stages of summer maize: VE – vegetative and emergence stage; V6 – 6th leaf stage; VT – vegetative tassel stage; R2 – blister stage; R6 – physiological maturity stage. In each growing season, values followed by different letters are significantly (P < 0.05) different among treatments

Grain yield. Over the three growing seasons from 2020 to 2022, DH605 consistently achieved the highest grain yield compared to TY808 and ZD958 (Table 2). The grain yield of DH605 was increased by 10.78% and 6.5% in 2020, 8.9% and 8.2% in 2021, and 4.3% and 6.8% in 2022, respectively, compared to that of TY808 and ZD958.

No significant differences in spike numbers were observed among the various cultivars. However, genetic disparities played a pivotal role when assessing the number of rows per spike. DH605 showed significantly higher rows per spike than the other two cultivars, with 16.2% and 11.4% increase in 2020, 11.5% and 6.9% increase in 2021, and 11.4% and 6.8% increase in 2022, respectively. There was no significant difference in spike number among different cultivars. Moreover, regarding kernel grains per row, TY808 demonstrated significantly higher values than the other two cultivars. In addition, DH605 also displayed the highest 1 000-kernel weight, followed by TY808 and ZD958.

Simultaneously, through path analysis on yield and various stages of SWS, we found that the VT (0.999) and R2 (0.495) stages significantly directly impacted yield, particularly the VT stage. Furthermore, the combined effect of the V12 and VT stages had the greatest influence on yield, followed by the VT and R2 stages (Table 3).

Water use efficiency. The WUE for summer maize was DH605 > ZD958 > TY808 (Figure 4). In 2020, there is no significant difference between ZD958 and TY808. However, DH605 showed a significant difference compared to TY808 and ZD958, with an increase of 14.6% and 7.2%, respectively. In 2021,

Table 2. The effect of summer maize cultivars on grain yield and yield components in 2020, 2021 and 2022 growing seasons

Treatment		Spikes number (spikes/m^2)	Rows per ear	Grains per row	1 000-kernel weight (g)	Grain yield (g/m^2)
	TY808	5.45^{a}	13.80^{c}	38.40^{a}	279.43^{a}	642.00^{b}
2020	DH605	5.96^{a}	16.47^{a}	34.07^{b}	280.33^{a}	719.63^{a}
	ZD958	5.93^{a}	14.60^{b}	37.60^{a}	257.15^{b}	672.67^{b}
	TY808	5.46^{a}	14.07^{c}	43.13^{a}	290.09^{a}	858.15^{b}
2021	DH605	5.83^{a}	15.9^{a}	39.84^{b}	297.31^{a}	942.59^{a}
	ZD958	5.83^{a}	14.8^{b}	37.67^{c}	289.46^{a}	865.74^{b}
	TY808	6.20^{a}	14.00^{c}	39.74^{a}	343.49^{ab}	1 075.92^{b}
2022	DH605	6.17^{a}	15.80^{a}	37.36^{b}	350.09^{a}	1 125.13^{a}
	ZD958	6.20^{a}	14.73^{b}	38.68^{ab}	337.66^{b}	1 074.48^{b}

In each growing season, values followed by different letters are significantly (P < 0.05) different among treatments

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Table 3. The impact of various stages of soil water storage (SWS) on grain yield. Path analysis of SWS and grain yield at different stages

Character	Single correlation coefficient	Direct path coefficient	Indirect path coefficient		
			V12–Y	VT–Y	R2–Y
V12	0.593	–0.102	–	0.979	–0.284
VT	0.649	0.999	–0.100	–	–0.250
R2	0.05	0.495	0.059	–0.504	–

V12 – 12th leaf stage; VT – vegetative tassel stage; R2 – blister stage; Y – grain yield

compared to the TY808 and ZD958, DH605 showed a significant increase in WUE by 11.6% and 10.8%, respectively. In 2022, DH605 exhibited an increase in WUE by 7.1% and 4.8% compared to TY808 and ZD958, respectively. These results indicate that, under the influence of rainfall, there is no significant difference in WUE between the TY808 and ZD958, while DH605 had the highest WUE.

DISCUSSION

Temporal and spatial distribution characteristics of soil moisture. In this study, we found that the effects of different water-sensitive cultivars of summer maize on soil moisture are different. DH605 cultivar exhibit a stronger influence on soil moisture during the middle and late reproductive stages than the other two cultivars. This could be attributed to its water-absorption solid characteristics, complex root system structure, and higher transpiration rate. Yan et al. (2022) indicated that the maize cultivars with a more complex root system structure have higher water absorption capacity. This suggests that the root system of DH605 may be more complex than the other two cultivars. Feng et al. (2019) compared the water consumption of maize in covered and non-covered fields at different scales and pointed out that a higher transpiration rate leads to increased root water uptake. Qi et al. (2012) pointed out that DH661 had faster root growth and higher density than ZD958, and DH661 had a more significant impact on soil moisture. Therefore, the significant impact of DH605 on soil moisture might be attributed to its root system and transpiration rate.

The response of soil moisture to summer maize with different cultivars hugely impacts biomass and water production (Li et al. 2019, Wei et al. 2019). Previous research showed that under sufficient water conditions, high water-sensitive cultivars presented a better performance characteristic than low water-sensitive cultivars (Ge et al. 2012). In our study, compared to the other two cultivars, DH605 exhibited greater changes in SWC, particularly in the deeper soil layers (80–120 cm), which were most pronounced during the V12 and VT stages. This is because, in the early and middle stages of growth, the root system of summer maize was primarily concentrated in the 20–60 cm soil layer (Sun et al. 2017), while during the later stages, the 40–80 cm soil layer became the area with the highest root density (Wu et al. 2021).

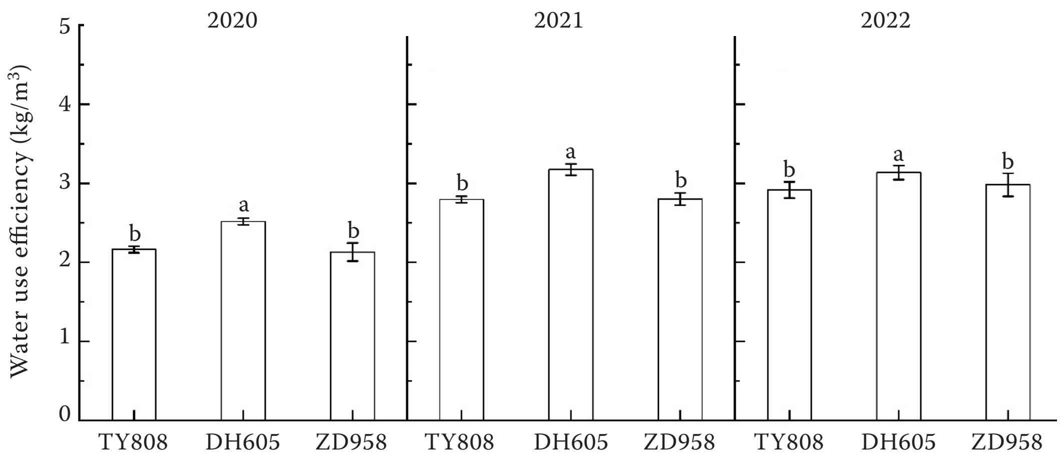

Figure 4. The effect of summer maize cultivars on water use efficiency in 2020, 2021 and 2022 growing seasons. In each growing season, values followed by different letters are significantly ($P < 0.05$) different among treatments

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This may be attributed to DH605's higher water absorption during the middle and later phases of the reproductive period.

Water consumption of summer maize. The appropriate water management strategies are crucial in improving crop WUE and achieving sustainable agricultural development (Mei et al. 2013). In this study, we observed that there is a high demand for water during the mid-stage (V12–R2) of crop growth (Table 1), while the water requirement gradually decreased in V6, R3, and R6. Water deficiency or excess during different stages of summer maize growth can have numerous adverse effects. For example, water deficit during the V12 stage could hinder the yield potential of summer maize and result in poor development of the ears (Li et al. 2018), while excessive SMC caused softening of the ear and increased susceptibility to breakage; this was consistent with the study of Liu et al. (2022). In the R2 stage, water deficiency led to dryness and incomplete milk maturity of the ears, affecting their size (Yin et al. 2016). Conversely, excessive SWC elevated the moisture level in the ears and grains, disrupting milk maturity (Yin et al. 2016). Maintaining proper irrigation management throughout these stages is crucial to mitigate these detrimental impacts and ensure optimal yield and quality of summer maize (Fatima et al. 2020). Water is also essential during the early growth stage of summer maize, as seed germination requires a certain level of moisture. When combining the water consumption levels at different stages, we can ascertain that SWS directly influences the yield during the V12–R2 stage (Li et al. 2020b), particularly in VT (Huang et al. 2023). We conducted path analysis on SWS and yield and found that the VT stage significantly impacts yield, with a direct path coefficient of 0.999 and a combined effect of V12 and VT with an indirect path coefficient of 0.979. This indicates that the VT stage significantly impacts yield, and ensuring normal soil moisture during the V12 stage is equally important for the growth and development of the VT stage. Sinha et al. (2021) studied the effect of stress combinations on crop reproductive processes; it is demonstrated that plant reproduction largely depends on an adequate supply of photosynthetic products. The VT stage of photosynthesis and nutrient accumulation significantly contribute to yield (Ren et al. 2023). Excessively high SWC during the VT stage can impact photosynthesis and respiration, consequently affecting normal growth and development during the R2 stage.

Analysis of grain yield and WUE of different water-sensitive cultivars. According to existing research, the adaptability of different cultivars to moisture change varies due to their water sensitivity (Engelbrecht et al. 2007). Yield components such as the number of spikes, the number of rows per ear, and the number of grains per row play a crucial role in determining the yield of summer maize (Huang et al. 2022). Our results showed that DH605 had more rows per spike than the other two cultivars, indicating its potential for high yield. However, both TY808 and the ZD958 had similar yields under rainfed conditions with sufficient rainfall. This finding aligns with previous research, which suggests that under sufficient water availability, compared to drought conditions, the yield difference between high water-sensitive cultivars and low water-sensitive cultivars will further narrow or exceed that of low water-sensitive cultivars (Islam et al. 2021). In addition, it is worth noting that DH605 consistently maintained a high number of rows per ear and total spikes number, ensuring stable and high crop yield.

Our experiment observed significant differences in water utilisation and WUE among the various water-sensitive summer maize cultivars. Specifically, DH605 demonstrated a higher total water consumption and greater WUE than the other two cultivars, resulting in a higher yield. Throughout the summer maize growth period, the ability to fully absorb soil moisture for summer maize represents a vital criterion in maize breeding.

However, our study only focused on the variation in water consumption of summer maize during different growth stages and did not conduct a detailed analysis of other environmental factors and crop growth conditions. Future research can integrate factors such as soil moisture, temperature, and light to establish a more comprehensive crop growth model, enabling a more accurate water consumption prediction in summer maize.

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