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Assessment of Yield Gaps in Timely and Late Sown Wheat Varieties in Low Fertility Loamy Sand Soil

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ABSTRACT

The performance of timely and late sown 13 wheat (bread and durum) varieties was assessed during rabi 2015-16 under irrigated and rainfed conditions in a low fertile loamy sand soil. Grain yield of timely sown bread wheat varieties varied between 4.89-5.74 t/ha, compared with 4.35-4.53 t/ha for late sown varieties. Grain yield of timely sown bread wheat varieties under rainfed conditions varied between 3.74 and 4.05 t/ha. In contrast, grain yield of timely sown durum wheat under irrigated conditions varied between 2.76-3.96 t/ha. Data revealed that an average grain yield of timely sown bread wheat varieties under irrigated conditions was 35.7% higher as compared to wheat varieties sown as rainfed. Timely sown bread wheat varieties sown under irrigated conditions yielded ~57 per cent higher grain yield, compared with durum wheat varieties. The production efficiency (PE) of timely sown bread wheat varieties under irrigated conditions was 4.5kg/ha/d (~15%) higher than sown as rainfed. It was higher by 12.9 kg kg/ha/d (61.7%) for timely sown bread wheat varieties, compared with durum wheat varieties under irrigated conditions. The PE was 5.2kg/ha/d (15.4%) lower for late sown bread wheat varieties, compared with timely sown varieties. Yield gap estimated over yield potential varied between 0.04-0.31 t/ha for bread wheat varieties sown under irrigated condition, compared to between 0.32-1.34 t/ha under rainfed condition. However, a yield gap estimated over yield potential for late sown bread wheat varieties under irrigated conditions varied between 0.35-0.36 t/ha, about 56 per cent higher than for timely sown wheat varieties.

Key Words: Bread wheat, durum wheat, production efficiency, yield gap, yield potential.

INTRODUCTION

Wheat (*Triticum spp.*) provides more protein than any other cereal crops. In Punjab, wheat is grown in rotation with rice, maize and cotton, constituting rice-wheat, maize-wheat and cotton-wheat cropping system. In Mansa, wheat is grown under rice-wheat and cotton-wheat cropping system. Wheat productivity of Mansa district is 4.4t/ha, against 4.7t/ha of Punjab (Anon, 2017). Majority of soils in Mansa are low in fertility with light texture and low soil organic carbon (OC), available P and K. Micro-nutrients particularly iron, manganese and zinc deficiency is frequently disturbing primary crop production besides soil salinity and alkalinity. The land productivity and estimates of additional crop yield that could be achieved by adopting recommended package practices could be assessed by measuring scale of yield gap (Singh *et al*, 2017). According to Fischer *et al* (2009), yield gaps cannot be reduced to zero due to practical and economic constraints. The concept of yield gap has been applied in many recent conducted studies (Liu *et al*, 2011) as an indicator for the possibility to increase crop yield in a given region. Therefore, an assessment of the performance of different wheat varieties was essential for identifying varieties suitable for low fertility soil. For this purpose, performance of thirteen (timely and late sown) bread and durum wheat varieties was assessed during rabi 2015-16 under irrigated and rainfed conditions in a low fertile loamy sand soil.

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MATERIALS AND METHODS

Experimental site

Field demonstrations were conducted at the KrishiVigyan Kendra, Khokhar Khurd, Mansa farm (latitude 30°02'54.728N and longitude 75°25'34.280E), India. The experimental area is characterized as hot dry, semi-arid and sub-tropical climate. Average annual rainfall in the study area is ~185 mm (Punjab Statistical Abstract, 2015), of which more than75 per cent is received during summer season extending from July to September and the rest about 20 per cent during the winter season.

Soil analyses

Surface (0-15 cm) soil samples were analyzed for pH (1:2 soil: water suspension) with a glass electrode and electrical conductivity (EC, 1:2 soil: water supernatant) using electrical conductivity meter (USDA, 1930). Available P in soil samples was determined by extracting with 0.5M sodium bicarbonate (pH 8.5; 1:20 soil: extract) (Olsen et al, 1954) and measuring P concentration in the extract calorimetrically (Murphy and Rilay, 1962). Available K in soil samples was extracted with 1N ammonium acetate (pH 7.0) (Mervin and Peech, 1950) followed by flame photometric determination. Micro-nutrients viz. zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) were determined from the diethylene amine tri-amine penta-acetic acid (DTPA) extract on atomic absorption spectro-photometer (Lindsay *et al*, 1978). Important physical and chemical properties of soil plough depth (0-15 cm) at the beginning of experiment are given in Table 1.

Table 1. Important physical and chemical characteristics of surface (0-15 cm) soil.

Property	Value
pH1:2	8.6
E.C.1:2 (d Sm-1)	0.12
Soil organic carbon (g/kg)	0.30
Available-P (mg/kg)	4.6
Available-K (mg/kg)	105
Soil texture	Loamy sand
DTPA-Zn (mg/kg)	0.30
DTPA-Cu (mg/kg)	0.30
DTPA-Fe (mg/kg)	3.78
DTPA-Mn (mg/kg)	2.01

Agronomic practices

Wheat crop was sown using seed rate of 100 kg/ha in the first week of November in rows 22.5 cm apart. As per the Punjab Agricultural University's recommendation the fertilizer N amount of 125 kg N/ha was applied to timely sown wheat under irrigated conditions, which is considered optimum for wheat. A basal dose of 62.5 kg P_2O_5 /ha was applied to wheat. Fertilizer P and half N (50% of recommended) was applied at sowing, while second half dose of N was applied with first irrigation. Wheat sown rainfed was applied at 80 kg N and 40 kg P_2O_5 /ha. Fertilizer P and half N (50% of recommended) was applied at sowing, and the second half at winter rains. Nitrogen and P were applied through urea and single superphosphate, respectively. Additionally, 25 kg $ZnSO_4.7\ H_2O$ / ha was applied. Since the experimental site was deficient in DTPA-Mn, four foliar sprays of 0.5% Mn were ensured, starting from 2-3 d before first irrigation to crop, and three such sprays thereafter at weekly interval. Irrigated wheat was adequately irrigated with ground water and an irrigation of about 7.5 cm was applied as and when required depending on the visual inspection of the field. The production efficiency was calculated for different fertilizer treatments by dividing the mean crop grain yield (kg/ha) by crop duration (days), according to the following equation.

Production efficiency (kg/ha/d) = Grain yield/ crop duration

RESULTS AND DISCUSSION

Plant height, biomass and harvest index

Plant height of different timely sown irrigated bread wheat varieties varied between 84.1 and 108.5 cm (mean=96.8 cm), compared with wheat sown varieties sown as rainfed (range=79.9-83.4; mean=81.2) (Table 1). Plant height of late sown irrigated wheat varieties varied between 77.9 and 81.8. Among different bread wheat varieties sown timely under irrigated conditions, wheat variety PBW 677 was the tallest and PBW 550 was the shortest variety. Grain yield of timely sown irrigated wheat varieties varied between 4.89 and 5.74 t/ ha1 (mean=5.28 t/ha). Grain yield of timely sown bread wheat varieties sown rainfed varied between 3.74 and 4.05 t/ha (mean=3.89 t/ha).

The results thus revealed that average grain yield of wheat varieties sown rainfed was 26.3 per cent lower, compared with wheat varieties sown with assured irrigation (Table 2).Grain yield of durum wheat varieties sown with assured irrigation varied between 2.76 and 3.96t/ha (mean=3.36t/ha), and was 36.4 per cent lower compared with bread wheat varieties.

The average grain yield of bread wheat varieties sown late under assured irrigated conditions was 4.44 t/ha, ~16% lower compared with timely sown wheat varieties. Straw yield of timely sown bread wheat varieties under assured irrigation conditions varied between 5.53 and 8.21 t/ha (mean=6.92t/ha), compared with bread wheat varieties sown as rainfed (5.08 and 5.32 t/ha; mean=5.20 t/ha).

In general, straw yield of different wheat varieties exhibit similar pattern to that of grain yield (Table 2). Harvest index (HI) of timely sown bread and durum wheat varieties sown under assured irrigation and rainfed conditions was nearly the same. However, HI of late sown bread wheat varieties was higher, compared with timely sown

Table 2. Plant height, grain and straw yield, harvest index (HI) and production efficiency of different wheat varieties.

Variety	Plant height (cm)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (HI)	Production efficiency (kg/ha/d)	Yield gap (t/ha) over		
						Yield potential	District average	State average
Timely sown								
Irrigated (Bread wheat)								
HD2967	98.7	5.21	7.16	0.42	33.6	0.14	0.77	0.49
HD3086	94.5	5.61	7.32	0.43	36.2	0.14	1.17	0.89
PBW550	84.1	4.89	5.53	0.47	32.9	0.31	0.45	0.17
PBW621	98.4	5.11	7.16	0.42	31.7	0.17	0.67	0.39
PBW677	108.5	5.47	7.37	0.43	35.3	0.13	1.03	0.75
WH1105	95.8	5.74	8.21	0.41	35.6	0.04	1.30	1.02
Rainfed (Bread wheat)								
PBW660	101.3	3.96	5.47	0.42	24.6	0.32	0.48	0.76
PBW644	102.8	2.76	3.95	0.41	17.1	1.34	1.68	1.96
Irrigated (Durum)								
PBW291	91.6	4.35	5.16	0.46	28.0	0.50	0.09	0.37
WHD943	83.8	4.53	5.26	0.46	29.2	0.42	-0.09	0.19
Late sown								
Irrigated (Bread wheat)								
PBW590	77.9	3.74	5.08	0.42	27.7	0.36	0.70	0.98
PBW658	81.8	4.05	5.32	0.43	30.9	0.35	0.39	0.67

varieties under assured irrigation conditions.

Production efficiency

Production efficiency of timely sown bread wheat varieties sown under assured irrigation conditions varied between 31.7 and 36.2 kg/ha/d (33.8 kg/ha/d), and exhibited a linear increase with increase in grain yield of different wheat varieties (Figure 1).

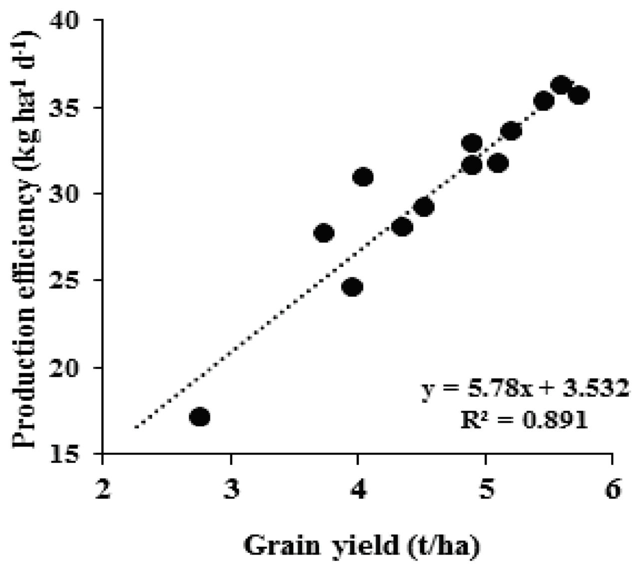

Figure 1. Relationship between wheat grain yield and production efficiency.

Average production efficiency of timely sown irrigated bread wheat verities was 61.7 per cent higher compared to durum wheat varieties (Table 2).The comparison of timely and late sown wheat varieties under assured irrigation conditions revealed that production efficiency of timely sown varieties was 18.2 per cent higher for timely sown wheat. Production efficiency of bread wheat sown as rainfed was 15.3 per cent lower compared with bread wheat sown under assured irrigation conditions.

Yield gap

Yield gap of different wheat varieties from potential yield varied between 0.04 and 1.34t/ha (mean=0.35t/ha) (Figure 2). Yield gap (A) from potential yield in case of irrigated timely sown wheat varieties was 0.17t/ha, followed by 0.36t/ha in case of late sown wheat varieties, 0.46t/ha in irrigated durum varieties and 0.83t/ha in case of rainfed wheat varieties. Wheat yield in demonstration plots was lower from potential yield with yield gap of 0.17-0.83t/ha. The demonstration plot yield of durum wheat varieties was at par with district average indicating no yield gap. The yield gap (B) for irrigated late sown bread wheat varieties was 0.55t/ha and it was maximum 1.08t/ha for rainfed timely sown bread wheat varieties.

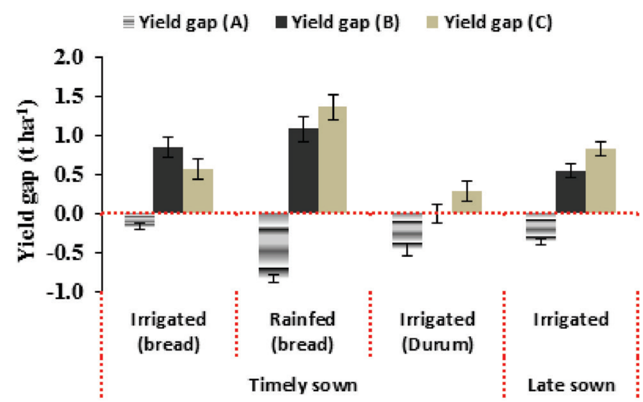

Figure 2. Yield gap of timely and late sown wheat varieties estimated over potential yield (A), district average (4.44 t ha-1) (B) and state average (4.72 t ha-1) (C).

The yield gap (C) depicts the difference in mean in obtained in demonstration plots with state average yield. It was minimum (0.28t/ha) for irrigated durum wheat varieties and was maximum (1.36t/ha) for timely sown rainfed bread wheat varieties. The yield gap (C) for timely sown irrigated bread wheat varieties was 0.56t/ha. The highest yield gap was recorded for PBW 644 and the lowest for WH 1105. Yield gap assessed from potential yield exhibited a linear decrease with increase in production efficiency. Yield gap of timely sown bread wheat varieties under assured irrigation was comparatively higher than for durum wheat varieties.

CONCLUSION

There was significant difference in yield for rainfed, irrigated, timely sown and late sown wheat crop under loamy sand soils from the potential yield. Enhancing yield of cereal crops is of utmost importance to meet the food needs of ever increasing human population. It is important to study existing yield gaps under different agro-climatic conditions, soils types, irrigation water quality and differential sowing times for crops under both irrigated and rainfed conditions. Existing analysis of yield gaps will act as road map to put necessary efforts for yield enhancement. The yield gaps at farmers' field could be attributed to poor soil health, poor water quality, lack of proper irrigation facilities and lack of adoption of best management practices. The yield gaps in demonstrations from potential yield will reveal the impact of poor soil health, water quality and sowing time on crop yield. Therefore, to achieve potential yield of different wheat varieties soil health needs to be improved.

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