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Effect of agronomical management practices on phenology, thermal use efficiency and yields of late sown wheat (*Triticum aestivum* L.)

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Abstract

Field experiment was conducted in sandy loam soil at CCS Haryana Agricultural University, Hisar, Haryana to assess the germination, attainment of phenophases and yields of late sown wheat under different agronomical management practices. The highest germination (m^{-2}) of wheat was observed in dry seeding with overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation. The attainment of heading, anthesis and physiological maturity took longer time in 15th December sown treatments as compared to 1st January sown treatments. The accumulated heat unit for particular phenophase is directly proportionate to duration of that phenophase, therefore, accumulated heat unit was observed higher with 15th December sown treatments as compared to 1st January sown treatments. The seed soaking and higher seed rate improved the thermal use efficiency over the dry seeding with normal seed rate. Similarly, soaked seed sowing also helped 2 days early germination. Among all the treatments, dry seeding of overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation resulted in significantly higher grain (4.20 t/ha) and biological yields (10.36 t/ha).

Key words: Dry seeding, seed soaking, germination, crop growth rate, grain yield.

Wheat (*Triticum aestivum* L.) is one of the important leading cereal crops which ranks first among world food crops, measured either by cultivated area (215.5 million ha) or by the production (670.9 million t) achieved (FAOSTAT, 2012). Wheat, with its root ramifying into the depths of human culture has an evolutionary history parallel with history of human civilization itself. Even today, it decides the feast or famine for millions of people. In India, wheat is the second most important cereal crop next to rice and a key crop of the green revolution and post green revolution era. India stands second among wheat producing countries with respect to area and production. The crop occupies an area of about 29.9 million ha with total production of 94.9 million *t* and a productivity of 3173 kg/ha and shares 14.14 percent of total production of world (FAOSTAT, 2012). However, in the past decade a general slow down in increase in the productivity of wheat has been noticed, particularly under environments relatively unfavorable for growth and development of wheat (Nagarajan, 2005). Current estimates indicates that in India alone around 13.5 million hectare of wheat is heat stressed (Joshi *et al*., 2007). During past few years, more than 50 per cent sowing of wheat often gets delayed till December or early January causing substantial loss in grain yield. The crop under late sowing suffer due to sub-optimal temperature at sowing which causes delayed germination, slow growth, development

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and low yield. The delayed sowing further causes supra-optimal thermal stress at reproductive phase which results in forced maturity (Gupta *et al.*, 2002). This high temperature stress at reproductive phase of crop resulted in poor yield due to reduced number of grains per spike and shriveled grain with low quality (Sharma *et al.*, 2007). The problem of high temperature stress will further aggravate with the global warming in the time to come. Hence, the present study was undertaken to minimize the yield losses of wheat grown under late sown conditions.

A field experiment was conducted at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar (at 29°10' N latitude and 75°46' E longitude and at an altitude of 215.2 M above mean sea level), during rabi season of 2007-08 to study the effect of different agronomic management practices on phenology and yields of late sown wheat. The soil of the experimental site was sandy loam, having 0.4% organic carbon, 171.6 kg/ha available N, 24.3 kg/ha available P, 309.4 kg/ha available K and 7.7 pH. The experiment was laid out in random block design with three replications. The experiment was comprising ten treatments viz. dry seeding on 15th December followed by irrigation, dry seeding with overnight soaked seed on 15th December followed by irrigation, dry seeding with 25% higher seed rate on 15th December followed by irrigation, dry seeding with overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation, dry seeding on 1st January followed by irrigation, dry seeding with overnight soaked seed on 1st January followed by irrigation, dry seeding with 25% higher seed rate on 1st January followed by irrigation, dry seeding with overnight soaked seed with 25% higher seed rate on 1st January followed by irrigation, dry seed sowing on 1st January after pre-sowing irrigation on 15th December and soaked seed sowing on 1st January after pre-sowing irrigation on 15th December. The experimental field was cross ploughed twice followed by planking to prepare a fine seed bed. The crop was sown on 15th December and 1st January during the 2007 and 2008, respectively. Sowing was done in rows spaced 20 cm apart at a depth of 5 cm. The recommended dose of nitrogen (150 kg N/ha), phosphorus (60 kg P_2O_5 kg/ha) and zinc sulphate (25 kg/ha) were applied. Irrigation was given at all critical stages of the crop. One weeding cum hoeing was done at 40 DAS with long tine hand hoe. All the necessary observations were recorded as per the established norms. Seedling emergence per m^2 was recorded at alternate day till the completion of germination in marked one m^2 area in each plot. Observations on emergence, heading, anthesis and physiological maturity were identified in each treatment as described by Peterson (1965). The heat units (HU) accumulated by crop for occurrence of various different phenophases in wheat was computed as per following the formula.

HU = [(maximum temperature + minimum temperature)/2] – Base temperature.

The base temperature for wheat crop was taken as 5°C. The thermal use efficiency (TUE) is computed as:

TUE (kg/ha day °C) = Yield/HU

After harvesting, the wheat crop was sun dried up to one week and then weight of net harvested area of wheat in each plot was recorded with spring balance. Grains were separated with a mini-plot thresher from biological yield obtained from each plot and converted into t/ha. The data relating to each character were analyzed as per the procedure of analysis of variance and significance tested by "F" test (Gomez and Gomez, 1984).

Results and Discussion

The number of seedling emerged at 16 DAS were observed highest (122) in dry seeding of overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation, however, it remained at par with dry seeding with 25% higher seed rate on 15th December followed by irrigation (118), dry seeding with 25 % higher seed rate on 1st January followed by irrigation (107), dry seeding of overnight soaked seed with 25% higher seed rate on 1st January followed by irrigation (108) and soaked seed sowing on 1st January after pre sowing irrigation on 15th December (100) (Table 1). The least number of seedlings were emerged in dry seeding on 1st January followed by irrigation. The reasons

Table 1. Effect of agronomical management practices on germination (plants/m²), development of phenophases, accumulated heat units and yields of late sown wheat

Treatment	Germination					Phenophases (DAS)				Yields (t/ha)		Harvest Index (%)
	8 DAS	10 DAS	12 DAS	14 DAS	16 DAS	Emergence	Heading	Anthesis	Physio-logical maturity	Grain	Biological	
DS-15 Dec-fbI	-	40	72	90	93	14.0 (104)	91.2 (757)	93.2 (788)	124.1 (1379)	3.75	9.19	40.8
DSWSS-15 Dec-fbI	47	67	92	93	95	12.1 (92)	89.2 (725)	92.2 (772)	124.0 (1379)	3.82	9.39	40.7
DS-25%HS-15 Dec-fbI	-	42	95	112	118	13.0 (98)	91.1 (757)	93.1 (788)	124.0 (1379)	4.10	10.15	40.4
DSWSS-25%HS-15 Dec-fbI	57	80	108	120	122	11.1 (84)	89.1 (725)	92.2 (772)	124..2 (1379)	4.20	10.36	40.5
DS-1Jan-fbI	-	10	40	75	83	16.3 (114)	84.0 (642)	86.0 (680)	114.0 (1173)	2.89	7.43	38.8
DSWSS-1Jan -fbI	-	53	82	87	88	14.0 (104)	83.2 (626)	85.1 (659)	114.0 (1173)	2.94	7.47	39.3
DS-25%HS-1Jan-fbI	-	8	32	98	107	15.2 (109)	84.0 (642)	86.2 (680)	114.1 (1173)	3.37	8.43	40.0
DSWSS-25%HS-1Jan-fbI	-	57	102	105	108	12.1 (92)	83.1 (626)	85.1 (659)	114.2 (1173)	3.40	8.70	39.0
DRSS-1Jan-apsI	-	38	78	88	97	15.0 (109)	84.0 (642)	85.9 (680)	114.1 (1173)	3.49	8.83	39.6
SWSS-1Jan - apsI	-	50	70	95	100	14.1 (104)	83.2 (626)	85.1 (659)	114.2 (1173)	3.54	8.87	39.9
C.D. (P=0.05)	-	15	23	24	22	1.67	1.79	1.96	1.89	0.09	0.20	0.86

*The values in parenthesis are accumulated heat units (Day °C)

DS: Dry seeding; FbI: followed by irrigation; DSWSS: Dry seeding with overnight soaked seed; DS-25%HS: Dry seeding with 25% higher seed rate; DSWSS-25% HS: Dry seeding with overnight soaked seed with 25% higher seed rate; ApsI-15 Dec: Soaked seed sowing after pre-sowing irrigation on 15th December, DRSS- Seeding of dry seed; SWSS-Seeding of overnight soaked seed.

for higher seedling emergence in dry seeding of soaked seed with 25% higher seed rate on 15th December followed by irrigation might be due to cumulative effect of 25 per cent of higher seed rate, overnight seed soaking with water and early sowing (15 days early than 1st January sown crop). The average 10% higher seedling emergence was observed only due to 15 days early sowing in 15th December sown treatments as compared to the 1st January sown treatments. The sowing of overnight water soaked seed resulted in 1.8 % increase of seedling emergence over the sowing of dry seeds whereas, 25 % higher seed rate boosted the seedling emergence by 25.3 % over that of normal seed rate. Average plant stand in 1st January sown crop was poor by 6.84 per cent than 15th December sown crop. This was due to delayed sowing. A slight reduction in germination under delayed sowing has also been reported by Sardana *et al.* (1999). In overnight water soaked seeds, the germination process was initiated much earlier as compared to unsoaked seeds. Similar findings were reported by Kahlon *et al.* (1992). The significantly higher plant stand per m^2 due to higher seed rate (150 kg/ha) than 125 kg/ha have earlier been observed by Azad *et al.* (1998).

The sowing of overnight water soaked seeds resulted in about 2 day earlier germination than the dry seeds (Table 1). The dry seeding of overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation took the minimum time (11 days) to complete emergence, while, dry seeding on 1st January followed by irrigation took the maximum time (16 days) for emergence. The average days taken by 15th December and 1st January sown treatments for emergence were 12.6 and 14.5, respectively. The reasons for early emergence in soaked seeds as compared to dry seeds might be the early initiation for germination. The favorable temperature on 15th December than that on 1st January could be the reason for early emergence of 15th December sown treatments as compared to 1st January sown treatments. The results are in conformity with the findings of Giri and Schillinger (2003).

The days taken to attainment of heading, anthesis and physiological maturity were significantly higher in treatments sown on 15th December as compared to those sown on 1st January. The attainment of heading, anthesis and physiological maturity was delayed by 6, 7 and 10 days respectively in the crop sown on 15th December. The early occurrence of various phenophases in 1st January sown treatments was because of heat stress owing to higher temperature during the reproductive phase which led to forced maturity (Nainwal and Singh, 2000). The accumulated heat unit is directly proportionate to duration of phenophases. The attainment of heading, anthesis and physiological maturity took longer time in 15th December sown treatments as compared to 1st January sown treatments, ultimately which resulted in higher accumulation of heat units in 15th December sown treatments. The physiological maturity occurred with accumulation of maximum heat units (1379 day °C) in all 15th December sown treatments. Whereas, in 1st January sown treatments only 1173 day °C heat units were accumulated. Sikder (2009) reported the higher accumulation of heat units for phenophases in normal sown wheat over the late sown wheat.

The thermal use efficiency (TUE, kg/ha day °C) in terms of grain and biological yield in figure 1 indicate that the thermal use efficiency in relation to grain yield was highest in dry seeding of overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation (3.04) followed by seeding of overnight soaked seed on 1st January after pre sowing irrigation on 15th December (3.01). However, highest thermal use efficiency in terms of biological yield was found in seeding of soaked seed on 1st January after pre sowing irrigation on 15th December (7.56) followed by seeding of dry seed on 1st January after pre sowing irrigation on 15th December (7.52).

The grain and biological yields were observed significantly higher in 15th December sown wheat than the 1st January sown wheat. Furthermore, among all the treatments, dry seeding of overnight soaked seed with 25% higher seed rate on 15th December followed by irrigation resulted significantly higher grain (4.20 t/ha) and biological yields (10.36 t/ha). The increased yield in dry seeding of overnight

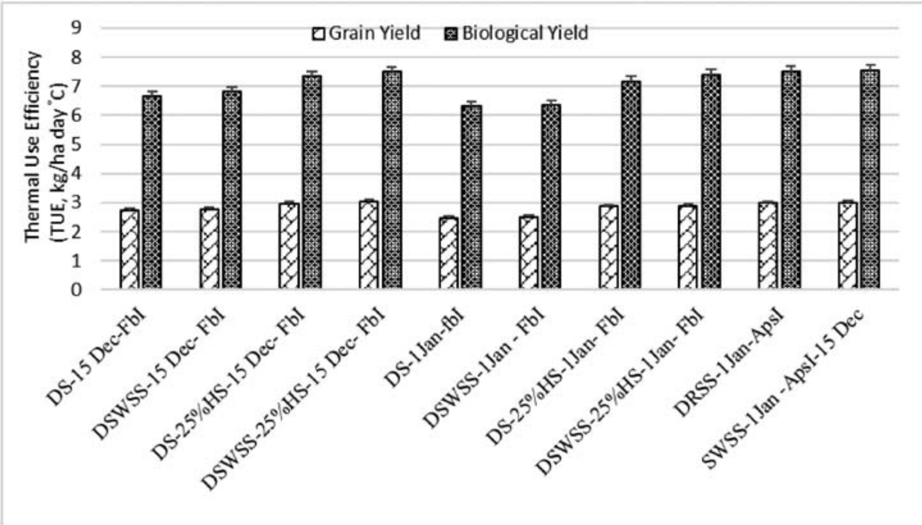

Fig. 1. Efffect of agronomical management practices on thermal use efficiency of grain and biological yields.

soaked seed with 25% higher seed rate on 15th December followed by irrigation attributed to better germination (46.3%) and early emergence (5 days) than the dry seeding on 1st January followed by irrigation. Another reason for higher grain and biological yield in 15th December sown treatments was extended vegetative and reproductive phase as compared to 1st January sown crop. The late planted crop was adversely affected during the reproductive phase because of supra-optimal thermal stress which leads to forced maturity as crop duration was shortened from 124 days to 114 days and reduced the HI also. Delay in wheat sowing 20 and 40 days from the normal sowing date (15th November) reduced grain yield by 23 kg/ha/day and 30 kg/ha/day, respectively (Kaur and Pannu, 2008).

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