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Kiran RG
M. Sc. (Agri.) in Agronomy, University of Agricultural Sciences, Dharwad, Karnataka, India.

Alagundagi SC
Professor, Department of Agronomy, University of Agricultural Sciences, Dharwad, Karnataka, India.

Correspondence
Kiran RG
M. Sc. (Agri.) in Agronomy, University of Agricultural Sciences, Dharwad, Karnataka, India.

Response of bread wheat (*Triticum aestivum* L.) genotypes to date of sowing and nutrient management for growth and yield under late sown irrigated condition

Kiran RG and Alagundagi SC

Abstract
Field experiment was conducted at Agricultural Research Station, Almel to study the effect of sowing date and nutrient management in bread wheat genotypes under late sown irrigated condition during *Rabi* 2014-15. Results revealed that, wheat genotype HD-3090 produced significantly higher grain yield (3628 kg ha^{-1}) compared to the genotype NIAW-34 (2710). The higher yield was due to the significantly higher performance of yield and growth parameters *viz*., number of tillers at 30 and 60 DAS (74.5 and 90.7 m^{-1}), number of productive tillers per m row length at both 60 DAS and at harvest (51.7 and 71.6, respectively) and dry matter accumulation at harvest recorded in per plant (6.83 g $plant^{-1}$). The crop sown on December 15th recorded significantly higher grain yield (3260 kg ha^{-1}) compared to December 30th sowing. The higher yield was due to the significantly higher performance of yield and growth parameters *viz*., number of tillers at 30 and 60 DAS (75.2 and 90.9 m^{-1}), number of productive tillers per m row length at both 60 DAS and at harvest (47.4 and 68.4, respectively), Fertilizer level of 125:93.75:62.5 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (3111 kg ha^{-1}) compared to 125:93.75:62.5 kg N, P_2O_5 and K_2O ha^{-1}. Higher interaction effect of wheat genotype HD 3090 sown on December 15th at fertilizer level of 125:93.75:62.5 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (3983 kg ha^{-1}) with better performance yield and growth parameters.

Keywords: Bread wheat, sowing date, fertilizer level

Introduction
Wheat (*Triticum aestivum* L.), is grown on more land area worldwide than any other crop and is a close third to rice and corn in total world production. Wheat production is about 70 million tonnes per year in India and counts for approximately 12 per cent of world production. Being the second largest in population, it is also the second largest in wheat consumption after China, with a huge and growing wheat demand. Wheat has a narrow geographic land base of production as compared to rice or pulses. Wheat is a temperate crop requiring low temperatures and most of the country is tropical. India wheat production increase is driven principally by yield growth and by shift in production from other crops to wheat and an increase in cropping intensity. Among the major factors that affect yield, fertilizer use appears to have less effect in recent years while expansion in irrigated and high yielding variety (HYV) area seem to play a more important role in raising yield. Depending on the population and income growth, poverty alleviation and the rate of urbanization, a demand-supply gap may open at a rate of about 1 to 2 per cent per year, which is equivalent to 0.7 to 1.4, million tonnes of wheat, growing larger over the years.

Importance of wheat in Indian agriculture is second only to rice. It is grown over an area of 29.8 m ha with total annual production of 95 m t and productivity of 3.2 t ha^{-1} (Anon., 2014) [1]. The states of Uttar Pradesh, Punjab and Haryana are the major wheat producers accounting for nearly 70 per cent of the total wheat produced in the country. Uttar Pradesh is the leading producer (25.03 m t) followed by Punjab and Haryana, while Punjab ranks first in productivity with 4207 kg ha^{-1} (Anon., 2014) [1].

Late planting affects the growth, yield and quality of wheat, because of shorter duration. Each day delay in sowing of wheat after 20th November onwards decreased grain yield at the rate of 36 kg ha^{-1} day^{-1} (Hussain *et al*., 1998) [4].

The genotypic response of wheat to planting dates varies for growth and yield contributing characters due to differential genetic potential. The decline becomes prominent in the cultivars requiring more days for heading under normal planting. Increase in temperature cause shortened heading period (Tashiro and Wardlaw, 1999) [11].

Similarly, cultivars matured earlier when planted late, indicating the forced maturity due to higher temperature. When optimum condition was provided to the wheat cultivar, grain filling period was higher as compared to late sown condition under high temperature stress at maturity. Being a thermo sensitive crop, sowing time plays a vital role in the growth and yield of wheat and therefore must be considered as a non-monetary input. Wheat being a heavy feeder of nutrients, heavy dose of fertilizers is a pre-requisite for higher yield. Not much work has been done on the effect of date of sowing and fertilizers on the growth and yield of wheat in the Zone 3 of Karnataka. The field experiment was planned with the objective to identify the profitable combination of bread wheat genotype, date of sowing and fertilizer level for higher productivity.

Materials and Methods

A field experiment on "date of sowing and nutrient management in bread wheat (*Triticum aestivum* L.) Genotypes for growth and yield under late sown irrigated condition" was conducted during *Rabi* 2014-15 at Agricultural Research Station, Almel, University of Agricultural Sciences, Dharwad (Karnataka). The experiment was laid out in split-split plot design with three replications. There were three genotypes (HD-3090, NIAW-34 and DWR-195) in main plot treatments, two sowing date (December 15th and December 30th) in sub plot treatment and two fertilizer levels (100:75:50 and 125:93.75:62.5 kg N, P_2O_5 and K2O ha^{-1}) in sub-sub plot treatments. The soil of the experimental site was *Vertisol* (medium deep black soil).

Nitrogen, phosphorus and potassium were applied as per treatment in the form of urea, di- ammonium phosphate (DAP) and muriate of potash (MOP), respectively. At the time of sowing half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose. Basal application was done in lines 5.0 cm by the side of the seed rows. The remaining 50 per cent nitrogen was top dressed at 30 days after sowing. The seeds were sown @ 150 kg ha^{-1} at 23 cm row spacing by opening furrows with the help of marker. The seeds were treated with *Azospirillum* @ 2.0 kg per ha seed rate before sowing. Later the seeds were covered manually. The crop was sown as per date of sowing *i.e.,* on 15th and 30th December, 2014. All the cultural methods were adopted as per the state recommended package of practices. Irrigations were given as per the crop requirement. The rainfall during the crop growth period was only 79.7 mm. However, lifesaving irrigation was provided to the crop. The crop was harvested at physiological maturity. The experimental data were statistically analyzed using MSTAT-C programme. The level of significance used in F test was P=0.05. The mean values of interaction treatment were subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values.

Results and Discussion

Effect of genotypes on growth parameters and yield

The bread wheat genotype HD 3090 recorded significantly higher grain yield (3628 kg ha-1) compared to other genotypes. The yield increase was 25.27 per cent, respectively compared to NIAW 34 and DWR 195, respectively. Significantly higher yield of genotype HD 3090 could be attributed to its thermo-tolerant nature and significantly higher performance of yield and growth parameters *viz.*, number of tillers at 30 and 60 DAS (74.5 and 90.7 m^{-1}), number of productive tillers per m row length at both 60 DAS and at harvest (51.7 and 71.6, respectively) and dry matter accumulation at harvest recorded in ear head (2.72g $plant^{-1}$) and per plant (6.83 g $plant^{-1}$) but significantly lower plant height recorded at 90 DAS and at harvest (75 and 79.4 cm respectively) compare to other genotype. Similar findings of higher grain yield in wheat genotype were reported by Bilagi *et al.* (2008) [2] and Singh *et al.* (2014) [8] due to better performance of yield and growth parameters. The significantly least grain yield recorded with genotype NIAW-34 (2710 kg ha^{-1}) was due to significantly lower performance of yield and growth parameters.

Effect of date of sowing on growth parameters and yield

The crop sown on December 15th recorded significantly higher grain yield (3260 kg ha^{-1}) compared to December 30th sowing. The yield increase with early sowing was 13.68 per cent over December 30th sowing. This was due to significantly higher performance of yield and growth parameters *viz.,* Plant height at 90 DAS and at harvest (81.1 and 87.5 cm respectively), number of tillers at 30 and 60 DAS (75.2 and 90.9 m^{-1}), number of productive tillers per m row length at both 60 DAS and at harvest (47.4 and 68.4, respectively) and dry matter accumulation at harvest recorded in ear head (2.55g $plant^{-1}$) and per plant (6.83g $plant^{-1}$). The significantly least grain yield recorded with crop sown on December 30th (2814 kg ha^{-1}) was due to significantly lower performance of yield and growth parameters. Similar results were reported by Shah *et al*. (2006) [7] and Tomar *et al*. (2014) [12].

Effect of fertilizer levels on growth parameters and yield

Fertilizer level of 125:93.75:62.50 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (3111 kg ha^{-1}) compared to RDF. The yield increase was 4.75 per cent compared to RDF. This was due to significantly higher performance of yield and growth parameters *viz.,* Plant height at 90 DAS and at harvest (79.9 and 86.6 cm respectively), number of tillers at 30 and 60 DAS (74 and 89.6 m^{-1}), number of productive tillers per m row length at both 60 DAS and at harvest (47.4 and 68 respectively) and dry matter accumulation at harvest recorded in ear head (2.49g $plant^{-1}$) and per plant (6.61g $plant^{-1}$). These findings are in agreement with Donaldson *et al.* (2001) [3] and Jat *et al.* (2013) [5]. The significantly least grain yield recorded with fertilizer level of 100:75:50 kg N, P_2O_5 and K_2O ha^{-1} (F_1, 2963 kg ha^{-1}) was due to significantly lower performance of yield and growth parameters.

Interaction effect of genotypes, date of sowing and fertilizer level on growth parameters and yield

The interaction $G_1D_1F_2$ *i.e.,* genotype HD 3090 sown on December 15th at fertilizer level of 125:93.75:62.5 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (3983 kg ha^{-1}). The grain yield increase was 38.08 per cent compared to 100:75:50 kg N, P_2O_5 and K_2O ha^{-1}. This was mainly due to significantly higher performance of yield and growth parameters. This might be due to optimum combination of genotype, date of sowing and higher fertilizer level. Though per plant performance was lower, the significantly higher number of tillers per m row length at 60 DAS (103.3), number of productive tillers per m row length at harvest (81.7) and dry matter accumulation per plant at harvest (7.33g) resulted in significantly higher yield. The significantly higher performance of individual effect of genotype (G1), date of sowing (D1) and fertilizer level (F2)

also contributed significantly to the higher yield with interaction of $G_1D_1F_2$. These results are in agreement with Kumar (1995) [6], Sing and Uttam (1995) [9]. The next best significantly higher interaction $G_1D_1F_1$ for grain yield (3851 kg ha^{-1}) was recorded with genotype HD 3090 sown on December 15th at fertilizer level of 100:75:50 kg N, P_2O_5 and K_2O ha^{-1}. This was mainly due to significantly higher performance of yield and growth parameters *viz.*, number of tillers per m row length at 60 DAS (91.7), number of productive tillers per m row length at harvest (73.3), dry matter accumulation in ear head (2.78 g) and dry matter accumulation per plant at harvest (7.27g). The interaction $G_2D_2F_1$ *i.e.*, genotype NIAW 34 sown on December 30th at fertilizer level of 100:75:50 N, P_2O_5 and K_2O kg ha^{-1} recorded significantly lower grain yield (2466 kg ha^{-1}) and also the growth parameters *viz.*, number of tillers per m row length at 60 DAS (72.3), number of productive tillers per m row length at harvest (52.7) and dry matter accumulation per plant at harvest (5.53g). This was due to significantly lower performance of growth and yield parameters with this interaction and the significantly least individual effect of genotype, date of sowing and fertilizer level. Similar results were also reported by Shah *et al.* (2006) [7], and Tahir *et al.* (2009) [10].

Table 1: Growth parameters and yield of bread wheat genotypes as influenced by date of sowing and nutrient management under late sown irrigated condition

Treatment	Plant height (cm)		Number of tillers per m row length		Number of productive tillers per m row length		Dry matter accumulation (g plant^{-1})				Grain yield (kg ha^{-1})
							Ear head		Per plant		
	90 DAS	At harvest	30 DAS	60 DAS	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	
Genotypes (G)											
G_1	75.0 ^{c}	79.4 ^{b}	74.5 ^{a}	90.7 ^{a}	51.7 ^{a}	71.6 ^{a}	1.38 ^{a}	2.72 ^{a}	5.44 ^{a}	6.83 ^{a}	3628 ^{a}
G_2	81.3 ^{a}	88.9 ^{a}	68.3 ^{b}	78.8 ^{c}	36.8 ^{b}	58.9 ^{b}	1.09 ^{c}	2.09 ^{b}	4.80 ^{c}	6.12 ^{c}	2710 ^{b}
G_3	79.4 ^{b}	87.9 ^{a}	73.9 ^{a}	89.0 ^{b}	44.9 ^{a}	64.6 ^{a}	1.23 ^{b}	2.59 ^{a}	5.11 ^{b}	6.46 ^{b}	2772 ^{b}
S.Em±	0.6	0.3	1.3	0.3	2.0	1.7	0.01	0.05	0.01	0.06	74
Date of sowing (D)											
D_1	81.1 ^{a}	87.5 ^{a}	75.2 ^{a}	90.9 ^{a}	47.4 ^{a}	68.4 ^{a}	1.26 ^{a}	2.55 ^{a}	5.20 ^{a}	6.83 ^{a}	3260 ^{a}
D_2	76.1 ^{b}	83.4 ^{b}	69.3 ^{b}	81.4 ^{b}	41.6 ^{b}	61.6 ^{b}	1.21 ^{b}	2.38 ^{b}	5.03 ^{b}	6.11 ^{b}	2814 ^{b}
S.Em. ±	0.6	0.2	1.3	0.4	0.7	1.2	0.01	0.04	0.02	0.05	34
Fertilizer levels (F)											
F_1	77.3 ^{b}	84.2 ^{b}	70.4 ^{b}	82.7 ^{b}	41.6 ^{b}	62.1 ^{b}	1.21 ^{b}	2.44 ^{a}	5.07 ^{b}	6.33 ^{b}	2963 ^{b}
F_2	79.9 ^{a}	86.6 ^{a}	74.0 ^{a}	89.6 ^{a}	47.4 ^{a}	68.0 ^{a}	1.26 ^{a}	2.49 ^{a}	5.17 ^{a}	6.61 ^{a}	3111 ^{a}
S.Em±	0.4	0.1	1.2	0.6	0.8	1.1	0.01	0.02	0.01	0.02	37
Interaction (GxDxF)											
$G_1D_1F_1$	76.4 ^{f}	79.9 ^{h}	76.7 $^{a-c}$	91.7 ^{c}	53.7 ^{b}	73.3 ^{b}	1.38 ^{b}	2.78 ^{ab}	5.48 ^{b}	7.27 ^{a}	3851 ^{a}
$G_1D_1F_2$	80.2 ^{d}	82.0 ^{g}	80.0 ^{a}	103.3 ^{a}	61.0 ^{a}	81.7 ^{a}	1.49 ^{a}	2.86 ^{a}	5.66 ^{a}	7.33 ^{a}	3983 ^{a}
$G_1D_2F_1$	70.2 ^{h}	76.9 ^{j}	69.3^{de}	81.7 ^{ef}	42.3 ^{d}	61.3 ^{cd}	1.28 ^{c}	2.57 ^{c}	5.24 ^{d}	6.13 ^{e}	3290 ^{cd}
$G_1D_2F_2$	73.2 ^{g}	78.8 ^{i}	72.0 ^{de}	86.0 ^{de}	49.7 ^{bc}	70.0 ^{bc}	1.36 ^{b}	2.66 ^{bc}	5.37 ^{c}	6.60 ^{c}	3390 ^{bc}
$G_2D_1F_1$	81.9 ^{bc}	90.0 ^{b}	68.3 ^{ef}	78.7 ^{f}	35.3 ^{ef}	57.7 ^{de}	1.08 ^{f}	2.28 ^{d}	4.81 ^{h}	6.37 ^{d}	2793 ^{f}
$G_2D_1F_2$	84.4 ^{a}	92.4 ^{a}	73.3 $^{b-e}$	85.7 ^{de}	41.0 ^{de}	63.3 ^{cd}	1.14 ^{e}	2.19 ^{de}	4.92 ^{g}	6.63 ^{bc}	3079 ^{de}
$G_2D_2F_1$	78.5 ^{e}	85.5 ^{e}	63.7 ^{f}	72.3 ^{g}	31.3 ^{f}	52.7 ^{e}	1.06 ^{f}	1.85 ^{f}	4.72 ^{i}	5.53 ^{g}	2466 ^{g}
$G_2D_2F_2$	80.4 ^{d}	87.8 ^{d}	68 ^{ef}	78.7 ^{f}	39.7 ^{de}	62.0 ^{cd}	1.10 ^{ef}	2.03 ^{e}	4.76 ^{hi}	5.93 ^{f}	2505 ^{g}
$G_3D_1F_1$	80.9 ^{cd}	89.0 ^{c}	74.7 $^{a-d}$	88.3 ^{cd}	43.7 ^{cd}	65.3 $^{b-d}$	1.22 ^{cd}	2.50 ^{c}	5.12 ^{e}	6.57^{c}	2888 ^{ef}
$G_3D_1F_2$	82.5 ^{b}	91.6 ^{a}	78.0 ^{ab}	98.0 ^{b}	49.7 ^{bc}	69.3 ^{bc}	1.26 ^{cd}	2.68 $^{a-c}$	5.20 ^{d}	6.80 ^{b}	2965 ^{ef}
$G_3D_2F_1$	75.6 ^{f}	84.1 ^{f}	70.0 ^{de}	83.7 ^{de}	43.0 ^{d}	62.0 ^{cd}	1.21 ^{d}	2.66 ^{bc}	5.03^{f}	6.10 ^{ef}	2489 ^{g}
$G_3D_2F_2$	78.8 ^{e}	87.1 ^{d}	73.0 $^{b-e}$	86.0 ^{de}	43.3 ^{d}	61.7 ^{cd}	1.23 ^{cd}	2.51 ^{c}	5.09 ^{e}	6.37 ^{d}	2746 ^{f}
S.Em. ±	1.0	0.3	2.9	1.4	1.9	2.7	0.02	0.05	0.03	0.05	89

DAS: Days after sowing

Means followed by the same lower case letter(s) in a column do not differ significantly by DMRT (P = 0.05)

G_1: HD 3090 D_1: 15-12-2014 F_1: 100:75:50 kg ha^{-1} N, P_2O_5 and K_2O (100% RDF)

G_2: NIWA-34 D_2: 30-12-2014 F_2: 125:93.75:62.5 kg ha^{-1} N, P_2O_5 and K_2O (125%RDF)

G_3: DWR-195

At 30 DAS

At 60 DAS

At harvest

General view of the experiment plot

Conclusion

The wheat genotype HD 3090 sown on December 15th at fertilizer level of 125:93.75:62.5 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (3983 kg ha^{-1}) with better yield and growth parameters in Northern dry zone of Karnataka during *rabi* season.

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