0RESPONSE OF NEW WHEAT GENOTYPE AT DIFFERENT DATES OF SOWING UNDER LATE SOWN IRRIGATED CONDITIONS

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Sumit Kumar Yadav

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July, 2005

(Sumit Kumar Yadav)
Author

Dr. R.D. Misra
Professor

Department of Agronomy
College of Agriculture
G.B.Pant University of Agric. and Tech.,
Pantnagar-263145, U.S. Nagar
Uttaranchal, INDIA

CERTIFICATE

This is to certify that the thesis entitled **"RESPONSE OF NEW WHEAT GENOTYPE AT DIFFERENT DATES OF SOWING UNDER LATE SOWN IRRIGATED CONDITIONS".** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** with major in **Agronomy** of the College of Post-Graduate studies, G. B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona fide* research carried out by **Mr. Sumit Kumar Yadav, Id. No. 30721,** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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July, 2005

(R.D. Misra)
Chairman
Advisory Committee

CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Mr. Sumit Kumar Yadav** Id. No. **30721**, a candidate for the degree of **Master of Science in Agriculture** with major in **Agronomy** agree that the thesis entitled **"RESPONSE OF NEW WHEAT GENOTYPES AT DIFFERENT DATES OF SOWING UNDER LATE SOWN IRRIGATED CONDITIONS"** may be submitted in partial fulfilment of the requirements for the degree.

(R.D. Misra)
Chairman
Advisory Committee

(Anand Prakash)
Member

(M.S. Yadav)
Member

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1 INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most extensively grown crop of the world. India is second largest wheat producer next to china and shares about 11.61% in total world production. In India wheat is cultivated during *rabi* season and covers major areas of Indo-gangetic alluvial plains. India harvested 740 mt of wheat with an average productivity of 29.0 q/ha during 203-04 (survey of Indian agriculture, 2003-04).

If wheat is sown late, the crop is induced to flower quite early due to onset of spring season cutting short vegetative phase which results in shortening of source and sink capacity. It has been proved conclusively that if wheat sowing is delayed beyond November, the yield will decrease @ 43 and 57 kg/ha/day in December and January crop, respectively (Misra *et al.,* 1996).

About 60-75% of the farmers sow wheat much after the optimal time of sowing in November under irrigated conditions. About 10 to 20% farmers sow wheat as late as in January (DWR, 2002). There is a growing tendency now-a-days to delay sowing of wheat for a different reasons in Western U.P., Bihar, W.B., Punjab, Haryana, Rajasthan and Maharashtra. This is mainly due to late harvesting of preceding corps like rice particularly. Late sowing crop experiences high temperature, declining relative humidity (R.H.) and hot desiccating winds in later stage of crop growth and also suffers from scanty rainfall with erratic distribution. Because of the crop exposure of to the abnormal climatic conditions, it gets a set back to its production.

In north-western region of the country, sowing of wheat is delayed either to fit it in multiple/relay crop sequences, where wheat is sown after a short duration *rabi* crop such as toria, potato and some vegetable crops or growing wheat after a fine quality scented rice and harvesting of sugarcane ratoon.

Delay in sowing caused slower germination and poor plant population due to lower temperature at time of sowing. The higher temperature in the later part of crop season, forced the late sown crop to mature almost with timely sown crop. This forced maturity affected the grain filling and grain weight, through adverse effect on nutrient uptake and translocation of nutrient for developing grains. Though it accelerate the initial grain growth rate but later on reduces the grain growth period and consequently the final grain weight is reduced. Under the availability or shorter growth period and temperature variations, the selection of suitable varieties is the most important options.

Wheat varieties show considerable variation in their performance in respect to variation in sowing time. In order to study the basis of yield variation among wheat varieties under different sowing conditions, it is essential to know the basic information on various physiological, morphological growth parameters and yield attributing characters which are responsible for variation in yield among the varieties. In view of the above facts the present investigation was undertaken to study the "Response of new wheat genotype at different dates of sowing under late sown irrigated conditions" was planned with following objectives:

1. To evaluate the relative performance of genotypes at different dates of sowing
2. To find out the optimum date of sowing in late sown condition for realization of potential production
3. To study the effect of wheat genotypes, dates of sowing on growth, development and yield parameters; nutrient up take and grain quality in terms of protein.

2 REVIEW OF LITERATURE

Research finding related to the performance of different wheat genotypes on the dates of planting on different varieties of wheat with special reference to growth, development, yield and yield attributing characters have been summarized under the following heads.

2.1 Effect of dates of sowing

2.1.1 Growth studies

2.1.1.1 Germination on emergence

Singh (1983) reported at Pantnagar that the different dates of sowing did not affect germination of wheat seed significantly under field condition in a study on 4 dates of sowing of wheat starting from November 4 to December 19. Tripathi (1983) observed that sowing dates did not influence seed germination significantly. The similar findings were also reported by Prakash (1985) for Pantnagar situation. Kumar (1990) while studying the effect of different dates of sowing (November 20, December 15 and January 5) and 5 varieties of wheat reported that emergence count at 15 days after sowing was not influenced significantly due to the dates of sowing. Singh *et al.* (1992), reported that 20.9 to 37.0 plants per metre row length during 1985-86 and 1986-87 when the crop was sown on 15 and 25 December. Raj (1997) and Kumar (1998) observed significant genotype influence on plant population at the time of germination.

2.1.1.2 Plant height

Plant height is one of the most important plant character which affecting lodging resistance among other plant characters.

Hari Kumar (1989) reported significant reduction in plant height with delayed in sowing from Nov. 17 to Dec. 29. Tewari (1990) observed significant reduction in plant height with dealy in sowing.

Sanwal (1993) and Raj (1997) found significant difference in plant height among various cultivars.

Plant height was not affected significantly due to sowing (Saikia *et al.* 2000). Mishra (2002) reported that delay in sowing resulted reduction in plant height.

2.1.1.3 Plant density

Mudhelkar (1981) observed higher number of shoot's in November 16 sown crop than December 16. Singh *et al.* (1983) reported a reduced number of effective tillers per plant in December 6 sowing than November. Sing *et al.* (1985) reported reduction in the number of effective tillers per plant in December sown crop in comparision to November sowing.

Choudhary (2004) observed higher number of shoots in December in 10 sown crop than January 05 sown crop.

Matsumura *et al.* (1988) reported that delay in sowing from November 8, to December 20 caused lesser number of shoots/m^2 but the differences were less marked towards the end of the growth period. Sharma and Choker (1989) reported that crop sown on 1st week of November recorded higher number of effective tillers per hill than crop sown on 1st week of December and January.

Sachan (1991) observed that December 15 sowing produced significantly lesser number of shoots at all the stage of growth than earlier sowing dates.

Singh and Singh (1991) reported 294.3 to 421.0 number of shoots/m^2 while taking 3 varieties of wheat sown on December 24. Spink *et al.* (2000) observed that plant population significantly affected the grain yield with a mean reduction from 9.2 to 5.5 t ha^{-1} as plant number was reduced 336 to 213 m^{-2}. In addition there was a significant interaction between plant density and sowing dates. There was, however, no interaction between variety and plant population in terms of yield. Mishra (2002) recorded that December 22 sowing produced significantly lesser number of shoots per unit area than timely sown crop.

2.1.14 Dry matter accumulation

Yadav and Sharma (1981) in their study at Pantnagar observed that plant dry matter accumulation with respect to time and treatments followed the sigmoid path. They observed that the rate of dry matter accumulation was very slow upto 40 days after sowing while it reached its peak upto 100 days after planting followed by decreased in growth rate till maturity. Dry matter accumulation at various growth stages was significantly influenced by dates of sowing.

A progressive decrease in dry matter accumulation was observed when the sowing were delayed from December 1 to January 10 (Prakash, 1985).

Matsumara *et al.* (1988) observed that dry matter production decreased with delay in sowing from November 13 to December 20. Kumar (1990) observed significant reduction in dry matter accumulation in whole plant at various stages of plant growth in each delay in sowing from November 5 to December 15. Singh *et al.,* 1995. The dry matter accumulation in leaf and stem has been reported to decrease significantly in both years of study when wheat was sown in November and December.

Satish *et al.* (1998) found that dry matter accumulation indifferent plant parts was significantly higher in the crop sown on 20 November as compared to crops sown on 1 November and 10 December. He also reported that dry matter accumulation at initial growth stages was higher in leaves but with the advancement of growth stages, it decreased and dry matter accumulation in stem increased.

2.1.2 Development studies

2.1.2.1 Days taken to germination

The time taken for seedling emergence increased with the delay in sowing (Singh, 1982). The similar results were also reported by Kumar (1990) and Sachan (1991).

2.1.2.2 Days taken to 50 percent heading

Sachan (1991) observed the reduction of number of days taken to heading significantly with delay in sowing from November 5 to December 15. Singh *et al.* (1997) reported significant reduction in the days of 50% heading in 10 wheat varieties sown from November 15 to January 15.

Choudhary (2004) reported that the number of days taken to 50 per cent heading was not affected by date of sowing.

2.1.2.3 Days taken to maturity

Samra *et al.* (1989) from PAU, Ludhiana reported that number of days taken to maturity decreased from 168 days for October 15 to

105 days from January 15 sown wheat. Singh (1997) reported significant reduction in days to maturity with the delay in sowing.

Choudhary (2004) reported that the number of days taken to maturity decreased as the sowing were delayed from December 10 to January 05.

2.1.3 Crop Productivity

Madhelkar (1981) observed that sowing of wheat around middle of November was found optimum and each delay of fortnight after November 15 resulted significant reduction in grain yield. Auti and Kangale (1985) reported significant reduction in grain yields with delay in sowing. Significantly higher yield was observed in December 1 sowing as compared to December 21, December 31, and January 10 sowing (Prakash, 1985).

Singh (1988) from Pantnagar reported progressive decrease in grain yield when the sowing were delayed from December 8 to January 4. Samra *et al.* (1989) reported decrease yield of all the 8 cultivars with delay in sowing from October 15 to January 15 at 10 days intervals.

Naik *et al.* (1991) reported that sowing on 31 October, 18 November or 15 November produced grain yields of 2.33, 2.57 and 3.30 t/ha, respectively. Jain *et al.* (1992) found significant reduction in grain yield by an average of 4.2, 22.3, 39.7 and 56.6 per cent with delay in sowing by 10, 20, 30 and 40 days, respectively compared with the crop sown on December 20.

Singh and Uttam (1994) reported that grian and straw yields of 12 varieties decreased with the delay in sowing from November 14 to December 4.

Choudhary (2004) reported higher grain yield was recorded in December 15 sown crop than January 05 sown crop.

Sinha *et al.* (2000) found that when sowing was delayed to 24 December and 3 January there was reduction in yield to the extent of 17.7 and 30.8 per cent, respectively, than sowing on 14 December. Kumar (1998) recorded significantly higher biological yields in normal sown crop (November 19) than late sown crop. Ibrahim *et al.* (2000) found that delayed planting are often associated with substantial grain yield losses, estimated upto 86% at farm level. He also found that delay in sowing date by one month reduced grain yield by 27% and genotype exhibited significant differential response to sowing date. Mishra (2002) reported that timely sown crop produced higher grain as well as biological yield than late sown corp.

2.1.4 Yield attributing characters

2.1.4.1 Number of spikes

Rao *et al.* (1980) reported reduction in number of spike/m^2 and 1000-grian weight as the sowing was delayed from November to January. Matsumura *et al.* (1988) reported that the reduction in number of ears as the sowing was delayed form November to December.

Naik *et al.* (1991) reported that the number of ear bearing tillers per plant was non-significantly affected by sowing dates. Jain *et al.* (1992) reported that late sowing starting from December 20 to January 29 significantly reduced number of spikes under irrigated conditions. Singh *et al.* (1995) while working at HIssar, reported that the number of effective tillers was significantly reduced from 103 to 95 and 130 to 117 tillers per meter in the year 1990-91 and 1991-92, respectively. Similar results als obtained by Das *et al.* (1996); Singh *et al.* (1997) and Singh and Uttam (1997).

2.1.4.2 Spike Length

Tripathi (1983) working at Pantnagar reported that dates of sowing from November 4 to December 19 caused significant difference in spike length. December 19 sown crop had significantly lower spike length as compared to November 4.

Kumar (1990), reported that spike length was significantly reduced from 9.9 cm in November to 8.5 cm in January 5 sowing. Singh *et al.* (1995) observed non-significant reduction in the ear length of wheat in both years of study. Das *et al.* (1996) reported decrease in the length of spike from 9.3 cm in 30 November to 8.7 cm in December 15 sown wheat. Mishra *et al.* (2002) reported that December 22 sown crop produced shorter spikes than November 22 sown crop.

2.1.4.3 Number of grains per spike

Radhey Shaym (1986) found that number of grains per spike was highest when crop was sown in third week of November. Singh (1988) reported significant reduction in grain number per spike when sowing were delayed from December 5 to December 17. Ansari *et al.* (1989) observed that the number of grain per spike tended to decline as sowing was delayed.

Naik *et al.* (1991) reported that 42.2 to 32.6 grains per spike in November 18 and December 15 sown wheat, respectively. This reduction in grain was statistically significantly. Such reduction in the grain per spike were reported by several other workers. Mishra (2002) reported that the number of grains per spike reduced with delay in sowing time. (Samra *et al.,* 1989; Kumar, 1990; Sachan, 1991; Das *et al.* 1996; Singh *et al.,*1997; Naik *et al.,* 1997 and Singh and Uttam, 1997).

2.1.4.4 Number of fertile spikelets per spike

Fertile spikelets per spike of wheat was influenced significantly by dates of sowing. Maximum fertile spiklets per spike were obtained from December 1, which were significantly higher than the spikelets from December 21, December 31 and January 10 sowings. Significantly minimum fertile spiklets were found in January 10 as compared to all dates of earlier sowing except December 1 (Prakash, (1985). The fertile spikelets per spike of wheat was influenced significantly by dates of sowing (Singh, 1988). Naik *et al.* (1991) reported the number of fertile spikelets per spike significantly decreased from 15.6 in November, 18 to 14.0 spikelets per spike in December 15 sown wheat. Thakur *et al.* (1995) obtained 15.80 to 19.20 spikelets per spike under late sown condition. Deor and Pathik (1997) recorded 14.3 and 17.5 number of spikelets per spike in control and fertilized treatment under late sown condition. Mishra (2002) reported that November 22 sown crop produced significantly higher number of fertile spikelets than December 22 sown crop.

2.1.4.5 Sterile spikelets per spike

Prakash (1985) found significant differences in sterile spikelets when sowing were delayed from December to January. Singh (1988) reported from Pantnagar that the sowing dates significantly influenced the number of sterile spikelets per spike. Lowest number of sterile spikelets per spike were recorded in December 17 sown crop.

Kumar (1990) recorded lowest nember of sterile spikelets per spike in November 20 sowing which was significantly lesser than January 5 sown crop. Sachan (1991) reported non-significant effect on the number of sterile spikelets due to dates of sowing but December 15 sown crop resulted highest member of sterile spikelets per spike. Mishra (2002) reported that delay in sowing times significantly increased the number of sterile spikelets per spike.

Choudhary (2004) reported number of sterile spikelets per spike was affected by sowing dates from December 10 to January 05.

2.1.4.6 1000-grains weight

Rao *et al.* (1980) reported reduction in 1000-grain weight as the sowing were delayed from November to January. Mustafa *et al.* (1987) observed that when wheat cv: Arz was sown on 4 dates between early November and late December. The 1000-grain weight increased from 38.34 to 49.62 g with earlier sowing dates. Singh and Verma (1990) reported that the dates of sowing significantly influenced the 1000-grain weight. The crop sown on

November 4 recorded significantly higher 1000-grain weight over crop sown on December 4. Kumar (1990) reported 42.3 and 36.5 g, 1000-grian weight in November 20 and January 5 sown crop, respectively.

It was significantly reduced in January 5 sowing as compared to November 30. Similar results were obtained by several other workers (Samra *et al.,* 1989; Sachan, 1991 and Singh and Uttam, 1997).

2.1.4.7 Nutrient uptake and protein content

Pandey *et al.,* (1991). Delay in sowing (15 days after normal sowing) significantly reduces the uptake of nutrients in grain and straws during 1983-84 and 1984-85 years.

Hossain *et al.* (1998) reported that nutrient uptake by grain highest at sowing on 1 December and lowest at sowing on 30 December. They also reported that grain protein content was lower with sowing on 15 November than with 1, 15 and 30 December sowing dates.

2.2 Varietal differences.

2.2.1 Growth studies

2.2.1.1 Germination count

Varieties had significant differences with respect to plant stand at germination (Singh, 1988), Kumar (1991) reported maximum plant stand in Raj-3232, which was significantly higher than PBW-225 and UP-2121. They further reported non-significant interaction between sowing dates and varieties. Singh and Singh (1991) observed significantly higher number of plant/m^2 in varieties HD 2329 while lowest in HD-1553.

Mishra (2002) reported that the highest and lowest plant stand at germination was recorded with PBW 343 and WH 896, respectively.

2.2.1.2 Plant height

Naik et al. (1991) reported significantly higher plant height in GW 120 and GW 89 than LOK 1 variety of wheat. Singh *et al.* (1995) reported significant variation among 7 varieties of wheat. Das *et al.* (1996) reported maximum plant height (100.3 cm) in C-306 and minimum (72.4 cm) in Sonalika.

Riaz *et al.* (1997) reported maximum plant height in Chitral Local. Sandeep Kumar (1998) working at Pantnagar found K-8962 as tallest and Raj 3765 as shortest variety among 10 wheat varieties sown on December 20.

Mishra (2002) working at Pantnagar found delay in sowing resulted reduction in plant height during both the years. Among varieties, the highest plant height was noticed in Raj-3077 followed by NIAW-34, while WH-542 produced shortest plants during both the years.

2.2.1.3 Plant density

Sachan (1991) reported significant effect of varieties on number of shoots at all the stages of growth except at 51 days after sowing at which variety PBW-251 gave maximum (300.8 shoots/m^2) while Raj-6392 gave minimum number of shoots/m^2 in HD-2329 and HD-1553, respectively. Singh and Singh (1996) observed 302 tillers/m^2 in variety HUW-234 on late sown wheat at Ghaghraghat (U.P.). Kumar (2002) reported that PBW-343 followed by UP-2338 recorded highest number of shoots under November 22 sown crop, whereas, UP-2425 followed by UP-2338 and Raj-3765 produced maximum number of shoots per unit area in December 22 sown crop.

Choudhary (2004) reported Raj-3765 produced higher number of shoots than genotypes PBW-373, UP-2425 and PBW-519 at 30 DAS. Whereas UP-2425 produced higher number of shoots at 90 days stage and at maturity.

2.2.1.4 Dry matter accumulation

Chang (1982) studied grain filling pattern and found that the grain growth curve was sigmoid and grain dry weight varied among varieties and it was mainly influenced by filling rate and the duration of the filling period.

Kumar (1990) reported maximum dry matter accumulation in whole plant for HD-2285 which was significantly higher than all varieties except PBW-226. The minimum dry matter accumulation in whole plant was recorded in Raj 3232. Sachan (1991) reported significant differences in dry matter accumulation in whole plant among different varieties. The maximum being with K-8704 at 112 days after sowing under Pantnagar condition. Singh *et al.* (1995) reported that dry matter accumulation in leaves and stem was significantly different due to variecties and varied from 119g/m leaves of WH-533 to 98 g/m in WH-416 and PBW-34 while from 333g/m in stem of varieties Raj-3077 to 252 g/m in PBW 34.

Satish *et al.* (1998) found that shoot dry matter in wheat variety HD-2329 was highest at 90 days stage and later on it become highest in WH 533 and WH 542.

Mishra (2002) reported that delay in sowing resulted reduction in total shoot dry weight at all the stages. At maturity stage the highest total dry weight was produced by PBW-343 followed by UP-2425 and UP-2338, while WH-542 and Raj-3077 recorded lowest total dry weight.

2.2.2 Development studies

2.2.2.1 Days taken to germination

Wali *et al.* (1989) observed that per cent germination of 15 wheat cultivars decreased when seed were maintained to temperature of 15-30^{0}C than at 10-25^{0}C but the percentage of abnormal seedlings was greater at the lower temperature. Sachan (1991) reported non-significant effect on days taken to germination due to verities.

2.2.2.2 Days taken to 50 percent heading

Sachan (1991) reported significant effect between sowing daters and varieties on days taken to heading. The maximum for varieties K-8704 and Raj-6392 while minimum for HD-2329.

2.2.2.3 Days taken for maturity

Samra *et al.* (1989) reported that varieties differed in the duration of maturity the varieties PBW-34 and DWL-5023 took longest day (140) for maturity while Sonalika took least days (130). Kumar (1990) observed that PBW-226 matured significantly earlier than all other varieties while HD-2285 took significantly more days to maturity than the other varieties except UP-2121.

Choudhary (2004) reported among four genotypes PBW-519, PBW-373, UP-2425 and Raj-3765. Genotypes PBW-519 matured earlier than other genotypes.

Mishra (2002) in his study at Pantnagar observed that late sown crop had shorter duration to maturity than timely sown crop. The largest and the shortest crop duration were observed in WH-896 and CPAN-3004, respectively.

2.2.3 Crop productivity

Naik *et al.* (1991) reported that GW-120 produced significantly higher grain yield (25.4 q/ha) as well as straw yield (36.1 q/ha) over other varieties while LOK-1 gave significantly lower grain yield (22.0 q/ha). Jain *et al.* (1992) reported that the lowest magnitude of loss in seed yield with delayed sowing up to January 19 was recorded in varieties LOK-1 and Raj-1555 which had average grain yield of 3.25 and 3.16 t/ha, respectively across all sowing and dates while greater loss recorded with HD-1533, HI-784, WH-147, G-405 and HD-1123.

Singh *et al.* (1995) reported that variety Raj -3077 gave maximum grain yield followed by WH-416 but minimum grain yield was recorded with PBW-34. Singh and Uttam (1997 a) reported that K-7410 gave highest grain yield although results were not significantly different from varieties K-8305, K-7229, K-8230, Sonalika, K-8152, Bithoor and K-8020. Singh and Uttam (1997 b) reported that variety K-816 gave higher yield when sown in December. Variety HP-1209 and HW-135 were more successful under late sowing (January). Harvest index was highest in variety K-816 Vivek Raj (1997) had also concluded and experiment during rabi 1996-97 at Pantnagar and found that out of 10 varieties, the highest and lowest biological yield was obtained from Raj-3765 and PBW-222, respectively. Rajender *et al.* (1998) found that the cultivars PBW 332 gave the maximum grain yield from all sowing dates (18 November, 12 December and 6 January), closely followed by UP 2338 and PBW 226. Sen (1999) found PBW-343 as the highest biomass yield and Hindi 62 as the lowest biomass yielder variety during his experimentation at Pantnagar.

Saikia *et al.* (2000) found that HUW-206 recorded the highest grain yield (32q ha^{-1}), which was statistically at par with HUW 484, NW 1038, K 9107 and HUW 468, but statistically superior to the rest of the varieties.

Choudhary (2004) reported among four genotypes the highest and lowest grain yield was obtained from genotypes PBW-373 and Raj-3765, respectively.

2.2.4 Yield attributes

2.2.4.1 Number of spikes

Samra *et al.* (1989) reported highest number of spike (64/m) in variety HD-2285 while lowest (51/m) in variety

SKAML-1. The maximum (134.4) and minimum (101.2) effective tillers/m^2 row length was reported from HD-2329 and GW 1021, respectively (Sachan, 1991).

Das *et al.* (1996) reported maximum (43.3/m) and minimum (34.1/m) number of spike from HP-1731 and K-8027, respectively. Singh *et al.* (1997) reported more number of productive ears in HP 2279, HI 1116, DW 120, Sonalika and LOK-1 and less number in HI 977, HI 1123, HD 1558, RHR-2825 and GIPS-1260.

2.2.4.2 Spike length

Sachan (1991) observed significant influences on spike length due to varieties and reported significantly longer spike (9.3 cm) in CPAN-3004 as compared to all other varieties except HD-2329. Singh *et al.* (1995) reported maximum (9.2 cm) and minimum (8.0 cm) ear length form WH-533 and PBW-34, respectively. They also observed that the length of ear differed significantly due to varieties. Das *et al.* (1996) reported maximum and minimum length of spike in variety TL 2780 and Sonalika, respectively. Mishra (2002) observed that the longest spikes were observed in PBW-343 followed by UP-2425, while the shortest spikes was noticed in WH-896.

2.2.4.3 Grain per spike

Sachan (1991) observed significantly higher number (46.9) of grains per spike in K-8704 over all other varieties except CPAN-3004, WH-882 and PBW-34. Das *et al.* (1996) found their number of grain per spike ranged from 32.9 to 49.4 in 6 varieties of wheat.

Singh *et al.* (1997) reported that sonalika and HUW 234 produced minimum and maximum number of grains pr spike, respectively. Riaz *et al.* (1997) found at Pakistan that Pivsabak-85 had the highest number of grain/spike and weight of grains/spike followed by Khyker-87.

Mishra (2002) recorded that variety UP-2338 produced highest number of grains per spike while NIAW-34 recorded lowest grains per spike.

2.2.4.4 Number of fertile spikelets

Sachan (1991) recorded significantly higher (17.5) fertile spikelets per ear in CPAN 3004 than all other varieties except GW-1021, PBW-215and Raj-6362. Thakur *et al.* (1995) reported minimum and maximum number of spikelets per ear as 15.27 in HP-1102 and 19.73 is HUW-376 during 2 years of experimental period. Mishra (2002) reported that the highest number of fertile spikelets in timely and late sown crops respectively.

2.2.4.5 Number of sterile spikelets

Sachan (1991) reported significant differences in number of sterile spikelets per spike among varieties and noted CPAN-3004 and HD-2329 produced significantly higher number (1.6) of strile spikelets per spike than all other varieties. The minimum (0.4) was produced by K-8704.

Mishra (2002) found that the lowest spikelet sterility was observed in PBW-343 while the maximum number of sterile spikelets per spike was observed in WH-542.

2.2.4.6 1000-grain weight

Samra *et al.* (1989) recorded minimum (34.0 g) and maximum (43.3 g), 1000-grain weight in variety WL-711 and PBW-54, respectively. Kumar (1990) reported varieties influenced 1000-grian weight significantly. PBW 226 produced highest 1000-grain weight as compared to other varieties. Lowest 1000-grain weight was recorded in UP-2121. Singh *et al.* (1997) reported higher 1000-grain weight in varieties HP-2279, HI 1116, DW-120, Sonalika and LOK 1 and lower in varieties HI 977, HI 1123, HD 1558, RHR 2825 and GIPS 1250.

Mishra (2002) recorded November 22 sown crop exhibited higher 1000-grain weight than December 22 sown crop. Varieties UP-2425 and CPAN-3004, produced the highest and lowest 1000-grain weight, respectively.

2.2.4.7 Nutrient uptake and protein content

Varietal variation in uptake of nutrients was also exhibited by grain and straw during 1983-84 and 1984-85 years. K-8020 showed the highest uptake of nutrient, followed by HD-1553, K-7807 and K-7903 (Pandey and Agrawal, 1991).

3 MATERIALS AND METHODS

The details of the experimental material, procedures and techniques followed during the course of investigation are described in the following heads.

3.1 Experimental Site

Field experiment was conducted in D3 plot of Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar during *rabi*-season of 2004-05. The centre is situated at 29^{o}N latitude, 79^{o} 29^{0} E longitude and an altitude of 243.84 metres above the mean sea level.

3.2 Climate and weather conditions

The climate of Pantnagar is sub-humid, sub tropical with hot and dry summers and cool winters. The Monsoon season generally extends from fourth week to last week of September. A few showers are expected during winter months (October to March). The winter season extends from November to March. During the winter season, frost generally occurs at the end of December and some times continues till the end of January. Weekly average of weather parameters such as minimum and maximum temperatures, relative humidity, rainfall and number of bright sunshine hours during the experimental period (Dec. to

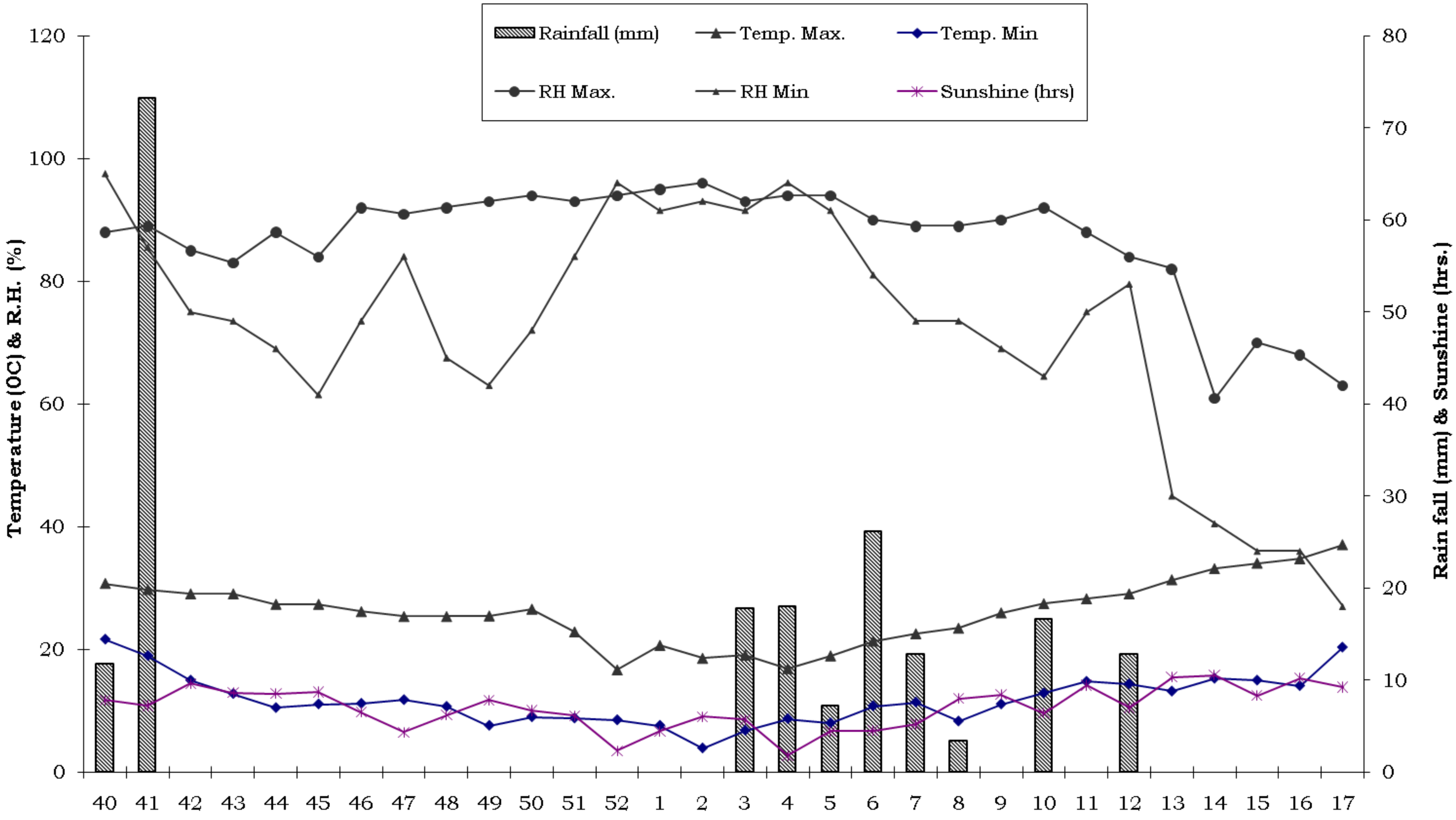


Fig 1. Weather conditions during crop season (2003-2004)

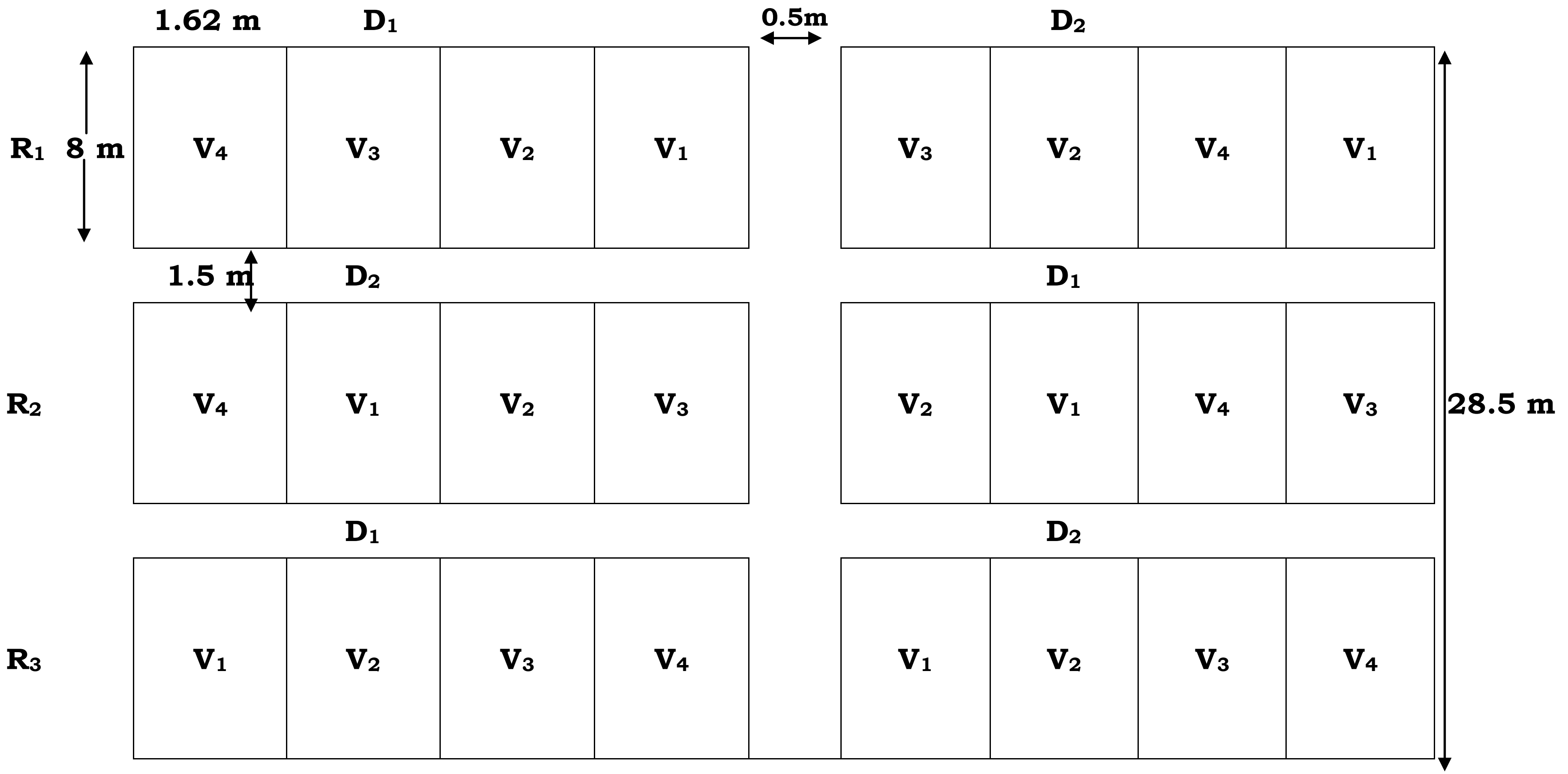
May) as recorded at the meteorological observatory located at Crop Research Centre, Pantnagar are depicted in Fig.1 and presented in Appendix I. Eighty two mm rainfall was received during the crop period. The weekly mean minimum and maximum air temperatures ranged from 20.9°C to 5.8°C and 38.4°C to 14.6°C, respectively. The weekly mean relative humidity varied from 62 to 97 percent and 17 to 72 percent at 7.00 am and 2.00pm respectively. At 7.00 am the highest mean relative humidity (97%) was recorded in second week of January and lowest (62%) in April. At 2.00 pm, the highest (72%) and lowest (17%) relative humidity was recorded in month of December and April, respectively. The weekly bright sunshine hours ranged from 2.1 to 10.1 hours. The maximum bright sunshine hours were recorded in March to April and minimum in December.

3.3 Soil Characterstics

The soils of this region are developed from calcareous, medium to moderately coarse textured materials under predominant influence of tall vegetation and moderate to well drain conditions. The experimental plot had silty loam soil which belongs to series III (Desh Pande *et al.,* 1971). A composite soil sample from 0-15 cm soil depth was collected before sowing of the crop and analyzed for important physico chemical characteristics. The chemical analysis of soil showed that it was rich in organic matter, low in nitrogen, medium in available phosphorus, medium in available potassium and neutral in reaction (table 1)

Table 1: Physical and chemical properties of experimentation

	Particulars	Value obtained	Method employed
i)	**Physical properties particle size distribution Sand %**		
	Sand (%)	52.02	Bouyoucas hydrometer method
	Silt (%)	34.04	
	Clay (%)	18.8	
	Bulk Density (g/cm^3)	1.35	
ii)	**Chemical properties**		
	Organic carbon (%)	1.07	Walkley and Black method (Black 1965)
	Available nitrogen (kg N/ha)	197	Alkaline KMNO4 (Subian and Asija (1956)
	Available phosphorus (Kg P/ha)	23	Olsen's method (Olsen *et al.,* 1954)
	Available potassium (Kg K/ha)	188	Flame emission spectrophotometer (Hanway and Hiedal 1952)
	pH (1:2.5) (soil: Water)	7.3	Glass electrode pH meter (Jacksom 1958)



Total plot area 8 m × 1.62 m = 12.96 m²

Net plot area = 7 m × 1.54 m = 7.56 m²

Fig. 2: Layout plan of the experiment

3.4 Cropping history

The cropping history of the plot are given below:

Year	Kharif	Rabi
2002-03	Maize	Wheat
2003-04	Maize	Wheat
2004-05	Maize	reported experiment

3.5 Experimental details

The experiment was conducted in a split plot design with dates of sowing in main-plot and genotypes in sub-plot treatment with three replications. The treatments are given below:

Main plot treatments

	(Date of sowing)	Symbol
(i)	December 15, 2004	D_1
(ii)	January 3, 2005	D_2

Sub-plot treatment (Genotypes)

(i)	DBW-16	V_1
(ii)	PBW-373	V_2
(iii)	UP-2425	V_3
(iv)	Raj-3765	V_4

3.6 Cultural operations

3.6.1 Seed bed preparation

The field was irrigated to have optimum moisture level for field preparation. After irrigation, the field was ploughed once followed by harrowing thrice and leveling and planking. Each time, the operations were done by tractor drawn implements. After that, the plots were marked according to the layout plan of the experiment.

3.6.2 Fertilizer application

The crop was uniformly fertilized with 120 kg N 60 kg P_2O_5 and 40 kg K_2O per hectare in the form of urea, single super phosphate (SSP) and muriate of potash, respectively. One third of the nitrogen alongwith full dose of phosphorus and potassium was applied as basal and incorporated well in to the soil with the help of a spade. The remaining two third of the nitrogen was top dressed at first node stage (30-35 days after sowing)

3.6.3 Sowing

The seeds of each variety were sown at the rate of 125 kg per hectare for both the dates. The seed was placed at 4-5 cm deep in furrows which were opened at a spacing of 18 cm with the help of plannet junior. The seeds were covered with soil.

3.6.4 Irrigation

The irrigation was given at late tillering, late jointing, flowering and milk stage.

3.6.5 Weed control

Pendimethalin (stomp) was sprayed at the rate of 1.0 kg ai per hectare in 700 liters of water, just after sowing of the experiment. Subsequent weedings were done by hand hoe and *'khurpi'*.

3.7 Harvesting and threshing

The crop was harvested with the help of sickles manually determined by visual observations. A 50 cm long row was harvested from each plot for post harvest studies. The produce from the net plot was bundled and tagged separately. Weight of bundles was recorded as biological yield (gain + straw) and the grain yield was recorded after threshing of produce with the help of Pullman thresher. Straw yield was calculated by subtracting the grain yield from the biological yield.

3.8 Observations

The observations in plant growth, development and yield contributing characters were recorded from two meter row length (2^{nd} row) from north side leaving border from both the side. All the values recorded were converted to one square meter area.

3.8.1 Growth studies

3.8.1.1 Emergence count

Plant emergence were counted in marked in observation area of one meter row length at 10 days after sowing in each demarcated area. It was finally expressed as plant emergence m^{-2}.

3.8.1.2 Plant height (cm)

Ten plants were randomly selected from the sampling area. The height was measured from base of the plant to the tip of the top most leaf and to the tip of the spike at different intervals of crop growth (30, 60, 90 days after sowing and at maturity).

3.8.1.3 Shoot count

The counting of shoots from the sampling area was done at 30, 60, 90 DAS and at maturity. The data converted to shoot count m^{-2}.

3.8.1.4 Dry matter accumulation (g)

At 30, 60, 90 DAS and at maturity the plants collected from the 25 cm row length from each plot from 2nd row north south side were dried in oven for 5 to 6 days at ± 70^{o}C and dry matter was recorded subsequently. Finally the dry matter accumulation was expressed in gram m^{-2}.

3.8.2. Development Studies

3.8.2.1 Days taken to germination

The number of plant was counted from the row length marked for taking the observation from the day when the first seedling emerged. The counting was continued on alternate days till the seedling number become constant. the data on which the total seedling become constant was considered as days taken to germination from sowing.

3.8.2.2 Days taken to 50 per cent heading

From the emergence of the first spike the number of shoots of each plot beared spike was counted on alternate days till more than 50 per cent of total number of shoots beared spike. The period taken for the emergence of 50 per cent spike from sowing date was counted.

3.8.2.3 Days take to maturity

For knowing the days to maturity the crop was maintained at two days interval as and when it started to turn yellow visually. The complete maturity of the crop was determined by making critical observation visually as well as by testing the doughness of grain by cutting grain with teeth.

3.8.3 Post harvest studies

3.8.3.1 Biological yield

The crop in each net plot was harvested bundled, labelled and dried in the field for 4-5 days. Bundles were weighed just before threshing to record biological yield per plot and expressed in q/ha.

3.8.3.2 Grain yield

The harvested produce of each net plot was weighed for recording the biological yield and then threshed for taking the grain yield. The grain yield (kg/net plot) was finally reported on the basis of quintal per hectare.

3.8.3.3 Straw yield

Straw yield per plot obtained by subtracting the grain yield from the total produce per plot. It was finally expressed in quintal per hectare.

3.8.3.4 Harvest index

Harvest index is the ratio of economic yield (grain) to biological yield (grain + straw) and calculated as follows:

$$\text{Harvest index} = \frac{\text{Grain yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

3.8.3.5 Grain to straw ratio

Grain to straw ratio was recorded as per following formula:

$$\text{Grain to straw ratio} = \frac{\text{Grain yield (q/ha)}}{\text{Straw yield (q/ha)}}$$

3.8.4 Yield attributing characters

Spike from 1m length of second row from the north side leaving border area of each plot were removed before harvest for spike characters studies.

3.8.4.1 spike length (cm)

Spike length was measured from its base upto the tip excluding awns.

3.8.4.2 Number of spikes/m^2

The number of spikes was recorded from the sampling unit at the time sampling unit at the time of maturity and data was reported as number of spikes per meter square.

3.8.4.3 Number of fertile spikelets

The number of spikelets bearing grains were counted from ten spike of the sample and average was taken and reported as fertile spikelets per spike.

3.8.4.4 Number of strile spikelets

The spikelets at the base and tip of the ten spikes which did not bear grains were counted and average was taken to get number or strile spikelets per spike.

3.8.4.5 Number of grain per spike

The same ten spikes were threshed and their total number of grains were counted. It's average has been reported as number of grain per spike.

3.8.4.6 Total weight of grain per spike

The ten spikes were threshed and then weighed. It's average has been reported as total weight of grain per spike.

3.8.4.7 1000-grains weight (g)

After threshing and weighing the net plot yield, a random sample of grain was drawn from the produce. Thousand grains were counted and weighed and expressed as total weight of 1000- grains.

3.8.5 Quality (chemical studies)

3.8.5.5.1 Nutrient content and uptake by crop

Nitrogen, phosphorus and potassium content were worked out in grain and straw (leaf + stem + husk) form the produce of sampling area. Oven dried seeds samples were ground with the help of willey mill grinder. Total N, P, and K contents were tested by modified Kgel dahl method spectrophotometetry and flame photometric method, respectively (Jackson, 1958). The uptake of N, P and K by grain and straw was calculated as procedure given below.

Nitrogen uptake (kg/ha)	=	N% × yield (q/ha)
Total nitrogen uptake	=	Nitrogen uptake by grain + nitrogen uptake by straw
Phosphorus uptake (kg/ha)	=	Phosphorus % × yield (q/ha)
Total phosphorus uptake	=	Phosphorus uptake by grain + phosphorus uptake by straw
Potassium uptake (kg/ha)	=	Potassium % × yield (q/ha)
Total potassium uptake	=	Potassium uptake by grain + potassium uptake by straw

3.8.5.2 Protein content

Nitrogen content of grain obtained by modified Kjeldahl method (Jackson, 1973) was multiplied by a constant value of 6.25 to obtained protein content in grain (A.O.A.C., 1960)

3.8.5.3 Protein yield

Protein yield was calculated with the help of following formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Grain yield (kg/ha)} \times \text{Grain protein content\%}}{100}$$

3.9 Statistical analysis

The experimental data were analyzed by standard statistical procedure for a split plot design (Panse and Sukhatme, 1985), Standard error of mean (S. Em ±) was computed in each case and critical difference (CD) at 5 per cent level of probability were calculated for significant differences only.

4 EXPERIMENTAL RESULTS

The results obtained during the course of investigation are presented in this chapter with appropriate tables and diagrams.

4.1 Growth studies

4.1.1 Germination count

The effect of dates of sowing on germination count at 15 days after sowing was significant though it was higher in December sown crop (Table 1 and Appendix V).

Maximum (270.5) number of germination count was observed in genotype Raj-3765. Which was significant higher than other genotypes. The minimum was observed in DBW-16 genotype.

The interaction between sowing dates and genotypes on germination count was significant (Table 2).

Higher number of germination count was observed under all the genotypes except DBW-16 when crop was sown on 15 December. The germination count was maximum under genotype Raj-3765 when crop was sown either on December 15 or 3 January. This indicates that with change in sowing date there was significant change in germination percentage of all the genotypes under testing.

Table 1: Effect of sowing dates and genotypes on germination count m^{-2}

Treatments	Germinations countm^{-2} at 15 DAS
Sowing dates	
December 15	222.0
January 03	193.0
S.Em.±	3.0
C.D. at 5%	14.1
Genotypes	
DBW 16	141.6
PBW 373	203.0
UP 2425	213.6
Raj 3765	270.5
S.Em.±	4.74
C.D. at 5%	14.6

Table2: Effect of sowing dates × genotypes on germination (countm^{-2})

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	144.0	139.5
PBW 373	215.0	190.6
UP 2425	230.6	196.6
Raj 3765	297.6	243.3
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	6.7	20.6
(ii) For comparison between two dates of sowing at same or different genotypes	6.3	21.9

4.1.2 Plant height

The data on plant height at various stages of growth as influenced by date of sowing and genotypes are summarized in (Table 3 and Fig 3) and the analysis of variance are given in Appendix II. Different dates of sowing showed significant differences in plant height at 60 DAS and maturity, non-significant at 30 and 90 DAS. December 15 sown crop attained maximum plant height at all the stages of growth. While under late sown conditions there was reduction in plant height of the genotypes under testing. Genotypes caused significant differences in plant height at 30. 60, 90 days after sowing and at maturity. Genotype Raj-3765 attained significantly higher plant height at 30 and 60 days after sowing except genotype UP-2425 which was at par to Raj-3765 at 30 days after sowing and at 90 days after sowing, genotype UP-2425 and Raj-3765 were at par to each other. Maximum plant height at maturity in genotype UP-2425.

The interaction effect of sowing dates and genotypes on plant height was significant only at 90 days stage (Table 4). Significantly maximum plant height in genotype UP-2425 under 15 December sown crop. Genotype Raj-3765 recorded significantly higher plant height than other genotypes under 3 January.

Table 3: Effect of dates of sowing and genotypes on plant height (cm) at 30, 60, 90 days after sowing and at maturity

Treatments	Plant height (cm)			
	Days after sowing			
	30	60	90	Maturity
Sowing dates				
December 15	18.5	40.2	80.0	88.1
January 03	18.0	32.7	75.1	79.2
S.Em.±	0.62	0.60	2.3	0.9
C.D. at 5%	N.S.	3.5	N.S.	4.2
Genotypes				
DBW 16	15.5	27.7	67.6	80.4
PBW 373	16.8	28.9	79.5	81.9
UP 2425	19.8	42.1	82.4	89.0
Raj 3765	21.3	47.1	80.6	83.2
S.Em.±	0.90	1.02	0.93	1.38
C.D. at 5%	2.7	3.1	2.8	4.2

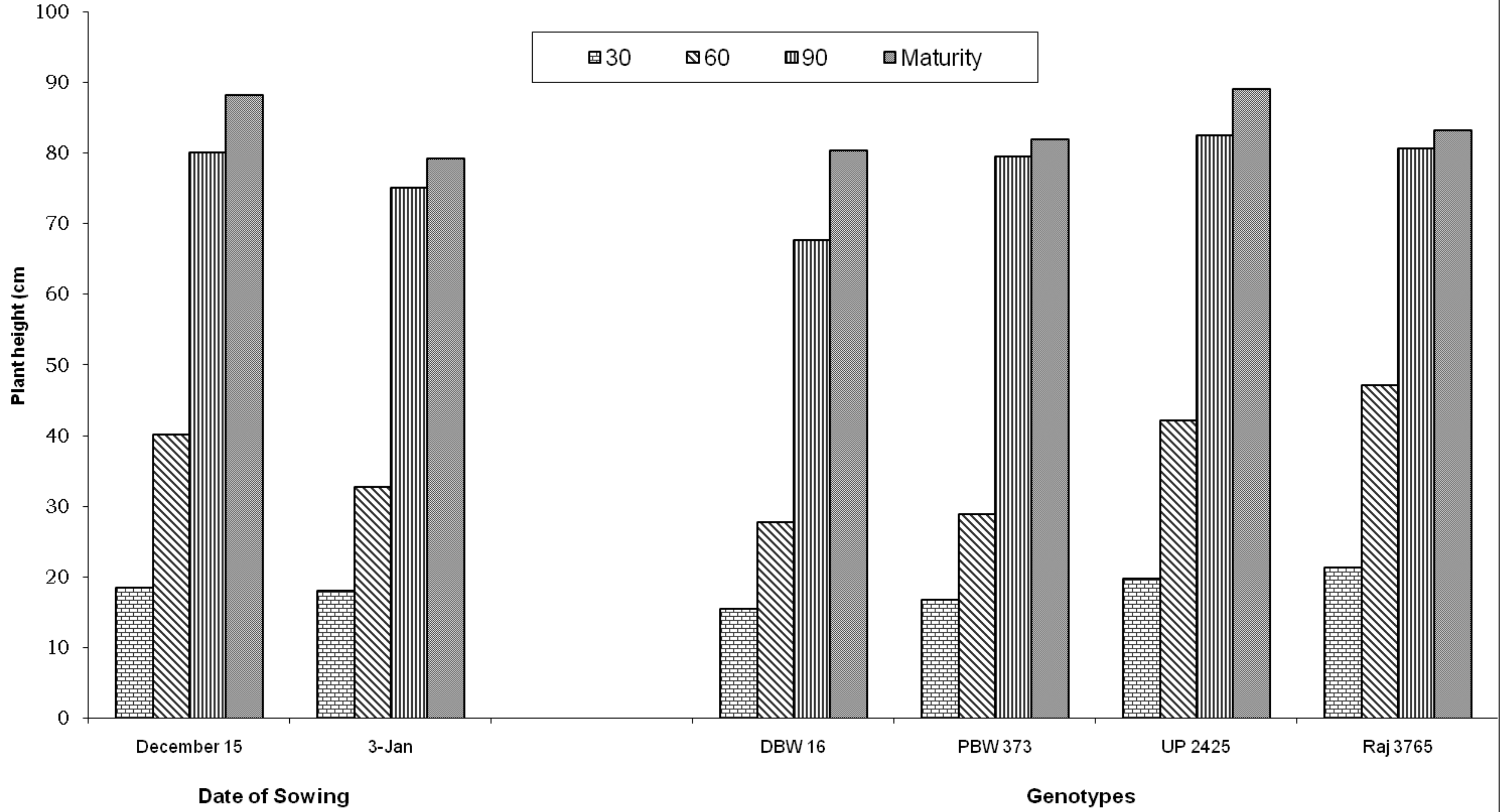


Fig. 3: Effect of dates of sowing and genotypes on plant height (cm) at 30, 60, 90 days after sowing and at maturity

Table 4: Effect of dates of sowing × genotypes on plant height (cm) at 90 days after sowing

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	72.3	62.9
PBW 373	81.4	77.6
UP 2425	86.4	78.4
Raj 3765	79.8	81.4
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	1.3	4.0
(ii) For comparison between two dates of sowing at same or different genotypes	1.7	5.3

4.1.3 Shoot count

The data on number of shoot/m^2 at various stages of growth as influenced by dates of sowing and genotypes are given in Table 5 and their analysis of variance are presented in Appendix III.

Different date of sowing showed significant difference for shoot count at 30, 60, 90 days after sowing and at maturity. Maximum number of shoots at various stages was observed in 15 December sown crop. Significant effect of genotypes on number of shoots was noticed at 30, 60, 90 days after sowing and at maturity. Genotype PBW-373 produced more number of shoots than other genotypes at 30 and 60 days after sowing. Genotype Raj-3765 produced higher number of shoots over other genotypes but at par with genotype UP-2425 at 90 days and at maturity.

The interaction effect between sowing dates and genotypes was significant with respect to number of shoots at 60, 90 dates after sowing and at maturity (Table 6a, 6b, 6c).

At 60 days after sowing genotype PBW-373 followed by DBW-16 produced slightly higher number of shoots than all other genotypes under 15 December sown crop.

Genotype PBW-373 produced slightly higher number of shoots than all other genotypes under 3 January sown crop.

Table 5: Effect of sowing dates and genotypes on shoots count m^{-2} at 30, 60, 90 days after sowing and at maturity

Treatments	Shoot count (m^{-2})			
	Days after sowing			
	30	60	90	Maturity
Sowing dates				
December 15	322.8	359.9	379.1	377.7
January 03	280.0	310.5	347.8	348.0
S.Em.±	4.0	0.89	2.8	3.7
C.D. at 5%	23.7	5.2	10.7	11.2
Genotypes				
DBW 16	282.1	342.8	357.5	357.1
PBW 373	315.0	348.6	360.1	359.0
UP 2425	303.8	330.8	366.6	365.8
Raj 3765	304.6	318.5	369.6	369.5
S.Em.±	6.6	3.8	2.4	2.5
C.D. at 5%	20.3	11.9	7.4	7.8

Table6a: Effect of dates of sowing × genotypes on number of shoots m^{-2} at 60 days after sowing

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	375.6	310.5
PBW 373	382.3	348.6
UP 2425	351.6	330.8
Raj 3765	330.0	318.5
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	5.5	16.9
(ii) For comparison between two dates of sowing at same or different genotypes	4.8	15.4

Table 6b: Effect of dates of sowing × genotypes on number of shoots m^{-2} at 90 days after sowing

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	379.0	336.0
PBW 373	380.3	340.0
UP 2425	378.3	355.0
Raj 3765	379.0	360.3
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	3.40	10.5
(ii) For comparison between two dates of sowing at same or different genotypes	3.46	13.3

Table 6c: Effect of dates of sowing × genotypes on number of shoots/m^2 at maturity

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	376.6	337.6
PBW 373	337.3	340.6
UP 2425	378.3	353.3
Raj 3765	378.6	360.3
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	3.6	11.1
(ii) For comparison between two dates of sowing at same or different genotypes	3.6	14.0

At 90 days after sowing genotype PBW-373 produced maximum number at shoots under 15 December while genotype Raj-3765 produced maximum number of shoots under 03 January sowing crop. Under December 15 sown, genotype DBW-16, UP-2425 and Raj – 3765 produced at par number of shoots to that genotype PBW-373.

At maturity, genotype UP-2425 and Raj-3765 produced almost equal number of shoots in 15 December sown crop. Genotype DBW-16 and PBW-373 at par with each other under 03 January sown crop, significantly higher number of shoots in genotypes Raj-3765 and at par with genotype UP-2425.

4.1.4 Total dry matter accumulation

The data on total dry matter accumulation in plant at different growth stages (30, 60, 90 DAS and at maturity) as influenced by dates of sowing and genotypes are summarized in Table 7 Fig 4 and Appendix IV.

Dates of sowing showed non significant differences in total dry matter accumulation at 30 and 90 days stage. At 60 days stage and at maturity the effect was significant. It was more in December 15 in comparison to January 03 sown crop. Significantly higher total dry matter accumulation observed under genotype DBW-16 at 60 days after sowing and at maturity there was seems to be non-significant effect under 30 and 90 days after sowing on the total dry matter accumulation.

Table 7: Effect of sowing dates and genotypes on total dry mater accumulation (g m^{-2}) at 30, 60, 90 days after sowing and at maturity

Treatments	Total dry matter accumulation (g m^{-2})			
	Days after sowing			
	30	60	90	Maturity
Sowing dates				
December 15	27.3	322.6	833.6	1408.1
January 03	15.9	268.4	624.0	951.6
S.Em.±	14.2	1.7	90.6	23.5
C.D. at 5%	N.S.	6.5	N.S.	139.3
Genotypes				
DBW 16	16.9	236.7	618.8	1064.7
PBW373	23.5	283.0	763.2	1108.8
UP 2425	21.7	298.6	670.1	1300.3
Raj 3765	24.4	363.0	861.8	1246.1
S.Em.±	24.8	2.7	76.6	51.8
C.D. at 5%	N.S.	8.5	N.S.	159.7

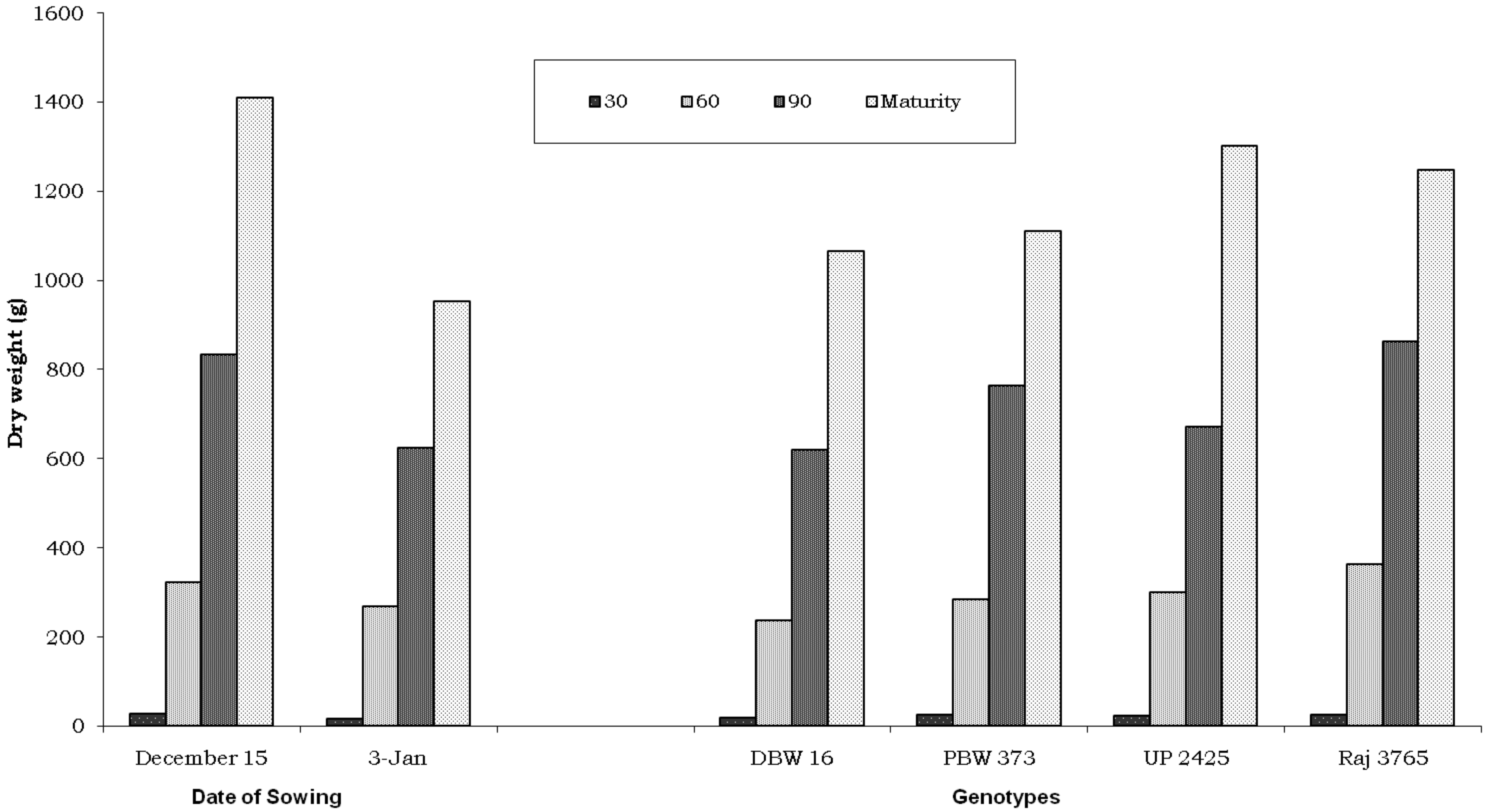


Fig. 4: Effect of sowing dates and genotypes on total dry mater accumulation (g m-2) at 30, 60, 90 days after sowingand at maturity

4.2 Development studies

The data on days taken to 50 per cent heading and days taken for maturity are summarized in Table 8 and appendix V.

4.2.1 Days taken to 50 percent heading

Number of days taken to 50 per cent heading decreased with delay in sowing from 15 December to 03 January. Though sowing dates highly significant influence the 50% heading.

Among genotypes, differences in days taken to 50 per cent heading were significant genotype DBW 16 took significantly more days to heading than other genotypes except PBW-373 which was at par with DBW-16.

Interaction effect between sowing dates and genotypes on days taken to 50 per cent heading was significant (Table 9).

Under 15 December sown, genotypes DBW-16 and PBW-373 took almost equal days for 50 per cent heading and genotype UP-2425 and Raj-3765 took more days to heading respectively. Under 3 January sowing DBW-16 and PBW-373 took almost equal days to 50 per cent heading followed by Raj-3765 and UP-2425.

4.2.2 Days taken to maturity

Sowing dates and days taken to maturity were significant (Table 8 Appendix V). Significant differences in number of days

Table 8: Effect of dates of sowing and genotypes and days taken for 50 percent heading and maturity

Treatments	Days taken to 50% heading	Days taken to maturity
Sowing dates		
December 15	81.3	118
January 03	70.1	105
S.Em.±	0.23	0.47
C.D. at 5%	1.3	2.7
Genotypes		
DBW 16	78.3	114
PBW 373	78.2	111
UP 2425	74.2	110
Raj 3765	72.3	110
S.Em.±	0.28	0.28
C.D. at 5%	0.86	0.88

Table9: Effect of dates of sowing × genotypes on days taken to 50 percent heading

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	84.3	72.3
PBW 373	84.3	72.0
UP 2425	79.3	69.0
Raj 3765	77.3	67.3
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.39	1.2
(ii) For comparison between two dates of sowing at same or different genotypes	0.41	1.6

to maturity were noticed due to genotypes. Genotype UP-2425 and Raj-3765 were matured earlier than genotype DBW-16 and PBW-373.

4.3 Crop productivity

The data on biological yield, grain and straw yield were summarized in Table 10 fig 5 and analysis of variance in Appendix VI.

4.3.1 Biological yield

Significant differences in biological yield were recorded due to sowing dates. December 15 sown crop produced significantly higher biological yield (91.5 q ha^{-1}) than January 03 (71.2 q ha^{-1}).

Differences in biological yield among genotypes were significant. Significantly higher biological yield (83.6 q ha^{-1}) was recorded under genotype DBW-16 over genotypes UP-2425 and Raj-3765.

The interaction effect between sowing dates and genotypes was significant (Table 11a). Under December 15 sown crop significantly higher biological yield observed in DBW-16 genotype (95.33 q ha^{-1}) and lowest in Raj-3765 (85.60 q ha^{-1}). Under January 03 sown crop genotype DBW-16 recorded significantly higher biological yield and genotype UP-2425 and Raj-3765 at par with DBW-16.

Table 10: Effect of sowing dates and genotypes on biological grain and straw yield (q/ha) harvest index and grain to straw ratio

Treatments	Biological yield	Grain Yield	Straw yield	Harvest Index	Grain straw ratio
Sowing dates					
December 15	91.5	37.1	54.4	0.399	0.68
January 03	71.2	28.3	42.8	0.393	0.66
S.Em.±	0.88	0.4	0.56	0.001	0.006
C.D. at 5%	5.20	2.4	3.40	N.S.	N.S.
Genotypes					
DBW 16	83.6	34.5	49.1	0.416	0.70
PBW 373	81.9	31.6	50.3	0.380	0.62
UP 2425	81.5	32.9	48.7	0.397	0.67
Raj 3765	78.4	32.0	46.4	0.400	0.68
S.Em.±	0.6	0.5	0.72	0.0054	1.5
C.D. at 5%	1.8	1.4	2.23	0.016	0.047

Table11a : Effect of date of sowing × genotypes on biological yield

Genotypes	Date of sowing	
	December 15	January 03
DBW 16	95.33	72.83
PBW 373	94.10	69.76
UP 2425	91.06	72.00
Raj 3765	85.60	71.20
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.84	2.6
(ii) For comparison between two dates of sowing at same or different genotypes	1.14	5.4

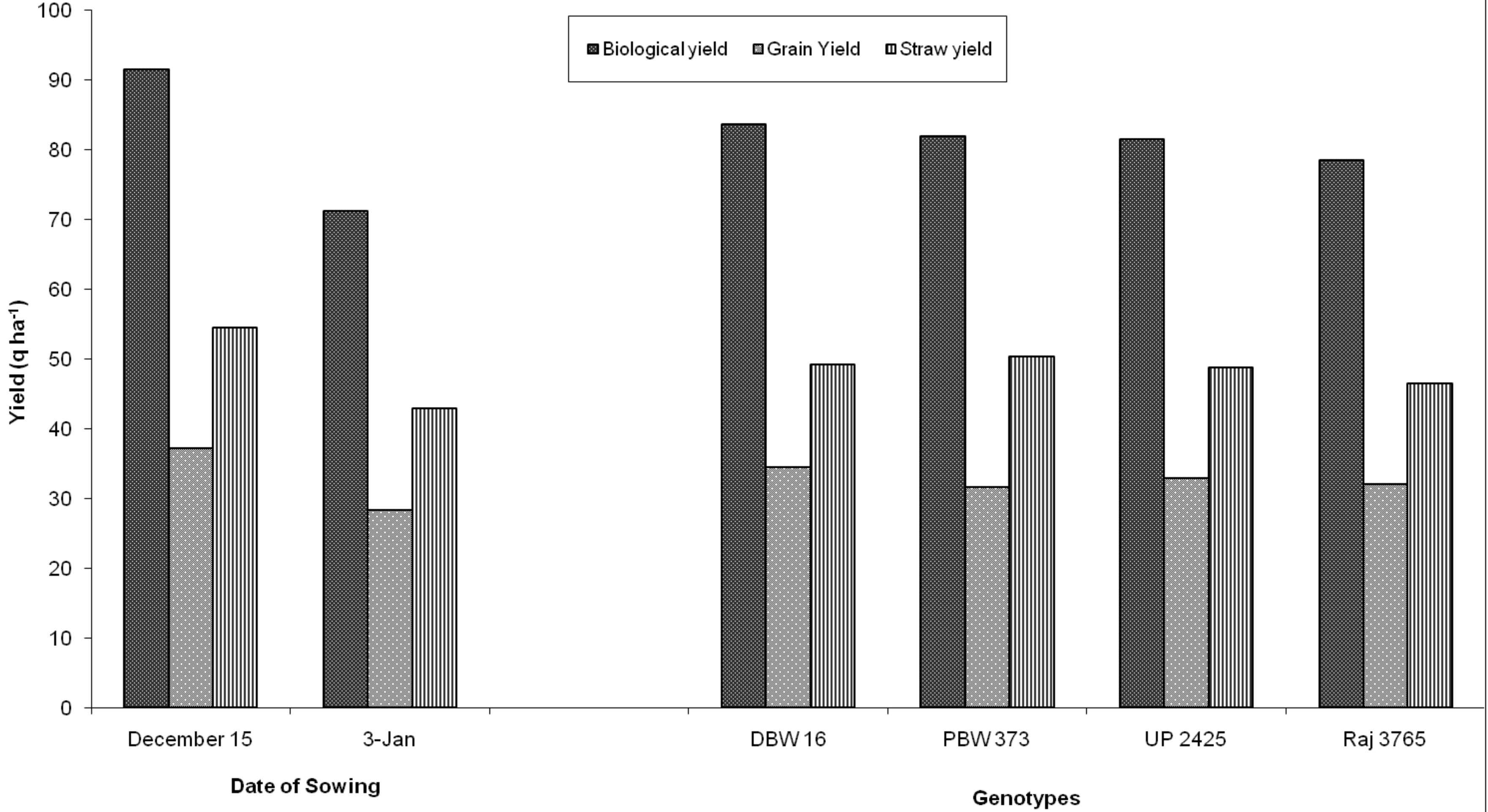


Fig. 5: Effect of sowing dates and genotypes on biological grain and straw yield (q/ha)

4.3.2 Grain yield

Significant differences in grain yield were recorded due to sowing dates. December 15 sown crop produced significantly higher grain yield (37.1 q ha^{-1}) than January 03 (28.3 q ha^{-1}). Among the genotypes also had a significant influence on grain yield. Genotype DBW-16 recorded significantly higher grain yield (34.5 q/ha^{-1}) than all other genotypes.

The interaction effect between sowing dates and genotypes was non-significant.

4.3.3 Straw yield

Sowing dates influenced straw yield significantly (Table10). December 15 sown crop produced significantly higher straw yield (54.4 q ha^{-1}) than January 3 (42.8 q/ha^{-1}) sown crop.

Genotypes also had a significant influence on straw yield significantly higher straw yield was produced in genotype PBW-373, (50.3 q ha^{-1}) which was at par with DBW-16 and UP-2425.

The interaction effect between sowing dates and genotypes was found significant (Table 11b). Under 15 December sown crop genotype PBW-373 (58.4 q ha^{-1}) produced significantly higher straw yield over Raj-3765 and UP-2425 but it was at par with genotype DBW-16. Under 03 January sown crop produced almost equal straw yield, highest straw yield was recorded in Raj-3765 and minimum from genotype DBW-16.

Table11b: Effect of dates of sowing × genotypes on straw yield

Genotypes	Date of sowing	
	December 15	January 03
DBW 16	56.3	41.9
PBW 373	58.4	42.2
UP 2425	53.8	43.5
Raj 3765	49.1	43.7
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	1.01	3.1
(ii) For comparison between two dates of sowing at same or different genotypes	1.04	4.0

4.3.4 Harvest index

Differences in harvest index due to sowing dates were present in (Table 10 and Appendix VI). December 15 sown crop, resulted in higher harvest index than January 03 sown crop. Among genotypes significantly higher harvest index in genotype DBW-16 over all other genotypes.

The interaction effect between sowing dates and genotypes harvest index was significant (Table 11c). Under December 15 sown crop recorded significantly higher harvest index in genotype Raj-3765 and genotype DBW-16 and UP-2425 resulted equal harvest index.

Under January 03 sown crop all genotypes produced almost equal harvest index.

4.3.5 Grain to straw ratio

Differences in grain to straw ratio due to sowing dates were significant (Table 10 and Appendix VI). There was also significant difference among genotypes.

Genotype DBW-16 produced significantly higher grain to straw ratio (0.70) and genotypes UP-2425 and Raj-3765 recorded at par value to grain to straw ratio.

The interaction effect between sowing dates and genotypes for grain to straw ratio was significant (Table 11d). Under December

Table11c: Effect of dates of sowing × genotypes on harvest index

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	0.40	0.41
PBW 373	0.37	0.39
UP 2425	0.40	0.39
Raj 3765	0.42	0.38
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.076	0.023
(ii) For comparison between two dates of sowing at same or different genotypes	0.006	0.022

Table11d: Effect of dates of sowing × genotypes on Grain to straw ratio

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	0.69	0.71
PBW 373	0.60	0.64
UP 2425	0.69	0.65
Raj 3765	0.73	0.62
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.021	0.061
(ii) For comparison between two dates of sowing at same or different genotypes	0.001	0.060

15 sown crop significantly higher grain to straw ratio produced in genotype Raj-3765 and genotype DBW-16 and UP-2425 recorded equal to grain to straw ratio in case of January 03 sown corp. genotype DBW-16 recorded significantly higher grain to straw ratio than all other genotypes.

4.4 Yield attributing characters

4.4.1 Number of spike m^{-2}

Sowing date showed non significant influence on spike m^{-2}, crop sown on December 15 produced more number of spike m^{-2} than January 5 sown crop (Table 12 and Appendix VII).

Among the genotypes differences due to dates of sowing on number of spike m^{-2} were also non significant slightly higher number of spike m^{-2} under genotype DBW-16 (352).]

The interaction effect between sowing dates and genotypes for number of spike m^{-2} was non significant.

4.42 Spike length (cm)

Sowing dates influenced the spike length (cm) non significantly. (Table 12) however longer spike were recorded at December 15 sowing over January 03.

Among genotypes had significant influenced for spike length significantly longer spikes (10.8 cm) were observed in genotype UP-2425 as compaired to genotype DBW-16 (8.6 cm).

Genotypes PPW-373 and DBW-16 attained almost equal spike length which was at par with genotype Raj-3765.

The interaction effect of sowing dates and genotypes for spike length was non-significant.

4.4.3 Number of fertile spikelets per spike

Sowing dates influenced the number of fertile spikelets per spike significantly (Table 12). Significantly higher number of fertile spikelets per spike were recorded under December 15 sown crop over January 03.

Among genotypes had non significant influenced for numbr of fertile spikelets per spike slightly higher number of fertile spike lets per spike were recorded under genotype DBW-16.

The interaction effect of sowing dates and genotypes on number of fertile spikelets per spike was non significant.

4.4.4 Number of sterile spikelets per spike

Sowing dates not influenced the number of sterile spikelets per spike significantly (Table 12). However January 03 sown crop produced higher number of sterile spikelets per spike over December 15 sown crop.

Among genotypes there was significantly differences in sterile spikelets per spike. Higher number of sterile spikelets per spike were observed in genotypes PBW-373. Genotypes Raj-3765 produced lowest number of sterile spikelets per spike.

Genotypes UP-2425 and DBW-16 produced at par number of sterile spikelets per spike.

The interaction effect of sowing dates and genotypes on sterile spikelets per spike was non significant.

4.4.5 Number of grain per spike

Sowing dates showed highly significant influence the number of grain per spike (Table 12). Although, December 15 sown crop produced significantly higher number of grain per spike over January 03 sown crop.

Among genotypes significantly higher number of grain per spike were produced in genotype DBW-16. Genotype PBW-373 produced lowest number of grain per spike. Genotype UP-2425 and Raj 3765 produced at par number of grain per spike with Genotype DBW-16.

The interaction effect between sowing dates and genotypes was non significant.

4.4.6 1000-grain weight

The differences in 1000-grain weight due to dates of sowing were significant (Table 12). Significantly higher 1000-grain weight was recorded in December 15 sown crop than January 03 sown crop.

The differences in 1000-grain weight due to genotypes was also significant. Significantly higher 1000-grain weight was

Table 12: Effect of dates of sowing and genotypes on number of spikes m^{-2}, spike, number of fertile spikelets, number of sterile spikelets per spike, number of grain per spike and 1000-grain weight

Treatments	Yield attributing characters					
	No. of spike m^{-2}	Spike length cm.	No. of Fertile spike lets/spike	No. of Sterile spikelets/spike	No. of Grain/spike	1000-grain weight (g)
Sowing dates						
December 15	365	9.4	16.6	3.7	34.3	35.8
January 03	339	9.1	14.7	2.4	28.9	34.1
S.Em.±	24.4	0.11	0.31	0.083	0.31	0.05
C.D. at 5%	N.S.	N.S.	1.8	N.S.	1.8	0.33
Genotypes						
DBW 16	352	8.6	16.1	2.5	32.8	35.0
PBW 373	349	8.8	15.2	2.9	30.8	33.3
UP 2425	333	10.8	14.8	2.7	31.3	33.4
Raj 3765	307	8.9	15.3	2.1	32.3	33.3
S.Em.±	36.7	0.2	0.7	0.1	0.6	0.5
C.D. at 5%	N.S.	0.6	N.S.	0.3	1.9	1.6

observed in genotype DBW-16 over other genotypes from genotype PBW-373 and Raj-3765 recorded equal 1000-grain weight.

The interaction effect between sowing dates and genotypes on 1000-grain weight was non significant.

The interaction between sowing dates and genotype on total dry matter accumulation was non significant.

4.7 Chemical studies

Plant nutrient accumulation

4.7.1 Nitrogen content

4.7.1.1 Nitrogen concentration in grain and straw

The data pertaining to nitrogen content in grain as well as in straw influenced by different treatments are given in Table 13 and analysis of variance are given Appendix –VIII.

Different in nitrogen content of grain and straw due to sowing dates were significant (Table13) December 15 sown crop, resulted in significantly higher nitrogen content than January 03 sown crop.

Genotypes also had a significant influence on nitrogen content in grain and straw. Genotype UP-2425 recorded significantly highest nitrogen content in grain (1.74) over other genotypes.

Genotype PBW-373 recorded significantly highest nitrogen content in straw (0.653) over other genotypes.

Table 13: Concentration and uptake of nitrogen at harvest as influenced by sowing dates and genotypes

Treatments	Grain (N)		Straw (N)		Total crop uptake N (kg P ha^{-1})
	Concentration (%)	Uptake (kg/ha)	Concentration (%)	Uptake (kg/ha)	
Sowing dates					
December 15	1.65	57.1	0.591	40.7	97.8
January 03	1.63	45.8	0.581	32.9	78.7
S.Em.±	0.001	0.58	0.0006	1.03	4.6
C.D. at 5%	0.008	3.4	0.003	4.14	12.65
Genotypes					
DBW 16	1.50	46.4	0.637	39.7	86.1
PBW 373	1.69	55.8	0.653	45.7	101.5
UP 2425	1.74	54.5	0.536	31.1	85.7
Raj 3765	1.63	49.0	0.516	30.6	79.7
S.Em.±	0.008	1.6	0.001	1.2	6.6
C.D. at 5%	0.025	5.2	0.004	3.9	20.5

The interaction effects between sowing dates and genotypes in respect to nitrogen content in grain as well as in straw were non-significant.

4.7.1.2 Nitrogen uptake in grain and straw

The data on nitrogen uptake in grain and straw are given in Table 13 and analysis of variance are given in Appendix-IX.

N uptake in grain was significantly affected due to sowing dates. December 15 sown crop, resulted significantly higher uptake than January 03 sown crop. N uptake in straw was affected significantly due to sowing dates. December 15 sown crop, resulted significantly higher uptake than January 03 sown crop.

Genotypes also had a significant influence on nitrogen uptake in grain as well as in straw. Genotype PBW-373 recorded significantly higher nitrogen uptake in grain (55.8 kg N ha^{-1}) but at par with genotype UP-2425 over Raj-3765 and DBW-16. In case of N uptake in straw genotype PBW-373 recorded significantly higher uptake over other genotypes.

The interaction effects due to sowing dates and genotypes on nitrogen uptake in grain as well as in straw were also non-significant.

4.7.1.3 Total crop uptake of nitrogen

The data on total crop uptake are given in table 13 and analysis of variance are given in Appendix-X.

Total crop uptake of nitrogen was not affected significantly due to sowing dates. December 15 sown crop, resulted higher uptake than January 03 sown crop.

Genotypes also had a significantly influence on total uptake of nitrogen. Genotype PBW-373 recorded significantly higher total nitrogen uptake (101.5 kg N ha^{-1}) but was at par with genotypes DBW-16 and UP-2425 over genotypes Raj-3765.

The interaction effect between sowing dates and genotypes was non-significant.

4.7.2 Phosphorus concentration

4.7.2.1 Phosphorous concentration in grain and straw

The data related to phosphorus content in grain as well as in straw were influenced by sowing dates and genotypes are given in Table 14 and analysis of variance are given in Appendix VIII.

Phosphorus content in grain and straw was not significantly affected due to sowing dates. December 15 sown crop, recorded higher content in grain and straw than January 03 sown crop.

Genotype also had a significant influence on phosphorus content in grain and straw. Genotype PBW-373 recorded

Table14: Concentration and uptake at phosphorus at harvest stage as influenced by sowing dates and genotypes

Treatments	Grain (P)		Straw (P)		Total crop uptake P (kg/ha)
	Concentration (%)	Uptake (kg/ha)	Concentration (%)	Uptake (kg/ha)	
Sowing dates					
December 15	0.314	10.9	0.095	6.5	17.4
January 03	0.304	8.5	0.089	4.9	13.4
S.Em.±	0.001	0.07	0.001	0161	0.181
C.D. at 5%	0.021	N.S.	0.004	0.563	N.S.
Genotypes					
DBW 16	0.327	10.0	0.099	6.2	16.2
PBW 373	0.337	11.1	0.103	7.2	18.3
UP 2425	0.285	8.9	0.083	4.6	13.6
Raj 3765	0.289	8.6	0.083	4.9	13.6
S.Em.±	0.001	0.29	0.001	0.19	0.46
C.D. at 5%	0.004	0.91	0.003	0.60	1.42

Table15: Effect of sowing dates × genotypes on phosphorus uptake in grain (kg p ha^{-1})

Genotypes	Date of sowing	
	December 15	**January 03**
DBW 16	11.8	8.3
PBW 373	12.8	9.4
UP 2425	9.6	8.2
Raj 3765	9.3	8.0
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.420	1.29
(ii) For comparison between two dates of sowing at same or different genotypes	0.371	1.18

significantly higher phosphorus content in grain and straw over other genotypes except that phosphorus content in straw, genotypes Raj-3765 and UP-2425 recorded equal phosphorus content.

Interaction effects between sowing dates and genotypes in respect to phosphorus content in grain as well as straw were non-significant.

4.7.2.2 Phosphorus uptake in grain and straw

The result on phosphorus uptake in grain and straw were summarized in Table 14 and analysis of variance in Appendix IX.

Phosphorus uptake in grain was affected significantly due to sowing dates. However, in December 15 sown crop recorded significantly higher uptake than January 03 sown crop. Phosphorus uptake in straw was affected significantly due to sowing dates. December 15 sown crop, recorded significantly higher uptake than January 03 sown crop.

Genotype also had a significant influence on phosphorus uptake in grain and straw. Genotype PBW-373 recorded significantly higher phosphorus uptake in grain (11.1 kg P ha^{-1}) and straw (7.2 kg P ha^{-1}) over other genotypes. Phosphorus uptake in grain was minimum in Raj-3765 and in case of straw genotype UP-2425.

The interaction effects due to sowing dates and genotypes on phosphorus uptake in grain was significant and non-significant in straw.

The interaction effects between sowing dates and genotypes on phosphorus uptake in grain was significant (Table 15). Under December 15 sown crop, significantly higher uptake in genotype PBW-373 and DBW-16 recorded at par to PBW-373 under January 03 sown crop, genotype PBW-373 recorded significantly higher uptake and DBW-16 at par with PBW-373.

4.7.2.3 Total crop uptake of phosphorus

The result on total crop uptake of phosphorus were summarized in Table 14 analysis of variance are given in Appendix X.

Total crop uptake of phosphorus was not affected significantly due to sowing dates. December 15 sown crop, recorded higher total uptake than January 03 sown crop.

Genotypes also had a significant influence on total crop uptake of phosphorus. Genotype PBW-373 (18.3 kg P ha^{-1}) recorded significantly higher total P uptake than other genotypes and lowest uptake in genotypes UP-2425 and Raj-3765.

Interaction effects between sowing dates and genotypes on total phosphorus uptake was non-significant.

4.7.3 Potassium

4.7.3.1 Potassium concentration in grain and straw

The data on potassium content in grain and straw were summarized in Table 16. and analysis of variance are given in Appendix VIII.

Potassium content in grain and straw was significantly affected due to sowing dates. December 15 sown crop recorded significantly higher content in grain and straw than January 03 sown crop.

Genotype also had a significant influence on potassium content in grain and straw. Genotype PBW-373 recorded significantly higher potassium content in grain and straw, over other genotypes except that potassium content in straw. Genotypes UP-2425 and Raj-3765 recorded equal potassium content.

Interaction effects between sowing dates and genotypes in respect to potassium content in grain as well as in straw were non-significant.

4.7.3.2. Potassium uptake in grain and straw

The data on potassium uptake in grain and straw were summarized in Table 16 and analysis of variance are given in Appendix IX.

Table 16: Concentration and uptake at potassium at harvest as influenced by sowing dates and genotypes

Treatments	Grain (K)		Straw (K)		Total crop uptake K (kg/ha)
	Concentration (%)	Uptake (kg/ha)	Concentration (%)	Uptake (kg/ha)	
Sowing dates					
December 15	0.677	23.5	1.75	119.6	143.1
January 03	0.602	16.9	1.67	94.7	111.6
S.Em.±	0.008	0.59	0.0003	2.8	2.8
C.D. at 5%	0.032	2.08	0.001	9.8	10.1
Genotypes					
DBW 16	0.650	20.1	1.71	107.1	127.2
PBW 373	0.740	24.7	1.76	123.2	147.9
UP 2425	0.600	19.1	1.68	98.1	117.0
Raj 3765	0.570	17.0	1.68	100.2	117.2
S.Em.±	0.006	0.60	0.009	3.5	3.9
C.D. at 5%	0.020	1.85	0.029	10.98	12.0

Potassium uptake in grain and straw was affected significantly due to sowing dates. December 15 sown crop, resulted higher uptake in grain and straw than January 03 sown crop.

Genotypes also had a significant influence on potassium uptake in grain and straw. Genotype PBW-373 recorded significantly higher potassium uptake in grain (24.7 kg K ha^{-1}) and straw (123.2 kg K ha^{-1}), over other genotypes. The minimum potassium uptake was recorded in grain in genotype Raj-3765 and in straw UP-2425.

The interaction effects due to sowing dates and genotypes on potassium uptake in straw was non significant.

Interaction effects between sowing dates and genotypes on potassium uptake in grain was significant Table 17a. Under December 15 sown crop recorded significantly higher uptake in genotype PBW-373 over other genotypes. Under January 03 sown crop significantly higher uptake of potassium in genotype PBW-373 over other genotypes and genotype UP-2425 recorded at par with PBW-373.

4.7.3.3 Total crop uptake of potassium

The data on total potassium uptake were summarized in table 16 and analysis of variance are given in Appendix-X.

Table17a: Effect of sowing dates × genotypes as potassium uptake in grain (kg K ha^{-1})

Genotypes	Date of sowing	
	December 15	January 03
DBW 16	24.6	15.6
PBW 373	29.3	20.1
UP 2425	20.8	17.3
Raj 3765	19.3	14.7
	S.Em. ±	C.D. at 5%
(i) For comparison between genotypes at the same date of sowing	0.84	2.61
(ii) For comparison between two dates of sowing at same or different genotypes	0.94	3.51

Total potassium uptake was significantly affected by sowing dates. December 15 sown crop, recorded significantly higher total uptake than January 03 sown crop.

Genotypes also had a significant influence on total crop uptake of potassium. Genotype PBW-373 recorded significantly highest total potassium uptake than other genotypes.

Interaction effects between sowing dates and genotypes in respect to total crop uptake of potassium was non-significant.

4.8 Protein content in grain

Significant differences in protein content were recorded due to sowing dates (Table 18 and the analysis of variance are given in Appendix-X). December 15 sown crop gave significantly higher protein content (10.3%) than January 03 (10.1 %) sown crop.

Genotypes also had as significant influence on protein content. Genotype UP-2425 (10.8%) recorded significantly higher protein content and genotype DBW-16 obtained minimum protein content (9.4%).

Interaction effect between sowing dates and genotypes was non significant and at par with genotype UP-2425 other genotype produced lowest shoots.

Table 18: Protein content in grain as influenced by date of sowing and genotypes

Treatments	Protein content (%)
Sowing dates	
December 15	10.3
January 03	10.1
SEm±	0.011
C.D. at 5%	0.039
Genotypes	
DBW 16	9.4
PBW 373	10.5
UP 2425	10.8
Raj 3765	10.2
S.Em.±	0.052
C.D. at 5%	0.160

5

DISCUSSION

In this chapter an attempt has been made to discuss the results of the experiment, to offer explanations and experimental evidences, wherever possible, for the noted variations to understand the ‘cause’ and ‘effect’ relationship as far as possible.

Yield in a crop is an additive result of the successful completion of the growth and development activities in individual plant, which in turn depends upon the hereditary potential of which it was exposed during the course of its life cycle. Therefore, to get maximum yield potential under a given set of agro-climatic conditions, it is essential that various factors of local plant environment are maintained at optimum levels. Several agronomical manipulations are possible to change. The local environmental conditions to such on extent that the yielding potential of the agro type could be exploited to its maximum. Growth and development of the plant is governed indirectly by the climatic factors such as temperature, relative humidity, rainfall and duration of sunshine hours. These parameters functions together and decide the pace of metabolic activities of the plant. Therefore, for determining the performance of wheat crop, particularly under late sown conditions, temperature seems to be the most important among climatic factors. Environmental conditions before anthesis influence the number and size of ear and thus determine the potential number of grain per spike. Environmental conditions after anthesis influence the size of grains and its weight.

Yield is the cumulative function of yield components namely number of spikes per unit area and grain weight. The later is a function of grain number per spike and 1000-grain weight.

5.1 Response of dates of sowing

The crop sown on December 15 produced significantly higher grain yield than January 03 sown crop. Similar results were also reported by Prakash (1985), Samra (1989). Jain *et al.* (1992), Das *et al.* (1996), Singh and Uttam (1997), Sinha *et al.* (2000) and Choudhary (2004). Increase in grain yield under December 15 sown crop was mainly due to favorable effect of dates of sowing on the growth, development and yield attributes. The capacity of plant to produce economic yield depends not on the size of photosynthetic system but also up on its efficiency and length of time for which it was active and also on partitioning of total dry matter to economically important plants. The final build upto yield was the cumulative function of yield components.

It was also observed that in general late (December 15) planted crop remained in vegetative phase (sowing to ear emergence) for longer period in comparison to very late sown

(January 03) December 15 sown crop produced more number of germination count than January 03 sown crop. Such delay in germination (January 03) may be due to fall in temperature. Days taken to 50 per cent heading different significantly due to sowing dates, crop sown such on December 15 took significantly more days to 50 per cent heading the January 03 sown crop. The crop sown in month of January was forced to mature without completing their normal development due to the prevalence of higher temperature during the later phase of growth.

Sachan (1991) and Singh *et al.* (1997) also reported the reduction in days taken to heading with delay in sowing. The crop under late sowing was subjected to shorter days with low temperature in the early stages of growth. Sharma *et al.*(1998) and Singh *et al.* (1997) also reported that the maturity was hastened as the sowing was delayed. Factors responsible for a short period from flowering to maturity in wheat crop are high temperature and long bright sunshine hours. Mudhelkar (1981) and Singh and Uttam (1994) also observed reduction in crop duration with delayed sowing after November 15.

The favorable effect on number of spike m^{-2} number of fertile spikelets per spike was also observed under December 15 sown crop, although the effect of dates of sowing on above character was observed to be significantly and number of grain/spike was also significant. Tripathi (1983), Naik *et al.* (1991), Thakur *et al.* (1999) and Choudhary (2004) also reported that the variation due to dates of sowing were significant. The reduction in grain yield of 19.4 per cent in case of very late sown crop (January 03) in comparison to December 15 may be due to high temperature during grain filling stage, resulted in lower number of fertile spikelets per spike and hence lower grain weight. The shortening of reproductive phase under January 3 sown crop attributes to decreasing production. December 15 sowing resulted longer spikes, increase in number of grain per spike and 1000 grain weight than January 3 sown crop.

Similar results were also observed by Das *et al.* (1996), Singh *et al.* (1991) and Singh and Uttam (1997). The spike length reduced under January 3 sown crop mainly due to reduction inreproductive period and higher temperature during the spike formation January 3 sown crop took almost 12 days lesser time for 50 percent heading and 22 days lesser time to maturity in comparison to December 15 sown crop. Both Maximum and minimum temperature showed arising trend with the advancement in crop growth. The highest value of 37.1^{0} C and 20.4^{0}C for maximum and minimum temperature, respectively were recorded in last week of April. The lowest value for maximum and minimum temperature 16.7^{0}C and 8.5^{0}C were recorded in the last week of December and 2nd week of January, respectively (Appendix-I).

Straw yield significantly decreased with delay in sowing. A reduction in straw yield of 21.7 per cent in very late sown crop (January 03) in comparison to December 15 sown crop was observed.

Reduction in straw yield with delay in sowing was mainly due to reduction in plant height, number of shoots/m^2 and total dry matter accumulation. Significantly taller plants were attained in December 15 sown crop at all the stages. A progressive decrease in plant height was observed as sowing were delayed. The plant height recorded periodically, showed that stem elongation in early stages was rapid and sub sequently it was slow. The late sown crop was subjected to long days with high temperature in its active growth period causes forced maturity without completing vegetative growth. Similar results were also reported by Samra *et al.* (1989), Das *et al.* (1996), Raj (1997) and Singh and Uttam (1997) Choudhary (2004). The number of shoots was significantly higher in December 15 sown crop at 30, 60 and 90 days after sowing. At maturity the effect was non significant. This might be because of the fact that temperature during tillering under January 3 sowing was comparatively lower than the earlier dates of sowing. Similar results were also reported by Sachan (1991) and Spink *et al* (2000).

Reduction in total dry matter production was observed under January 3 sown crop as compared to December 15 sown crop at various stages of crop growth this may be due to lower straw yield with delay in sowing. The either decrease in photosynthetic ratio or increase in temperature toward maturity. Almost similar harvest index under both the sowing may be due to the higher temperature during reproductive and ripening phase.

5.2 Response of genotypes

Variation in biological yield, grain yield and straw yield was significantly influenced by the genotypes. Significant variation among genotypes in grain yield were also reported by Naik *et al.* (1991), Choudhary (2004), Singh *et al.* (1998), Saikia *et al.* (2000). The grain yield (maximum) recorded in genotype DBW-16 was significantly higher number of days taken to 50 per cent heading, higher number of fertile spikelets and less sterile spikelets and higher 1000-grain weight over other genotypes.

Number of spikes per m^{-2}, 1000-grain weight and number of fertile spike lets per spike were significantly higher under DBW-16 genotypes and took more number of days for 50 per cent heading this may be the reason for highest yield under DBW-16 genotype.

The harvest index and grain to straw ratio was also significant by this genotype.

The interaction effect between dates of sowing and genotypes was significant for germination, plant height, number of shoots and non significant effect observed under total dry matter production at all the stages. The interaction effect for days taken to 50 per cent heading was also significant and non significant for days taken to maturity. Genotype DBW-16 and PBW-373 took almost equal days for 50 per cent heading under both sowing dates.

In general, the interaction effect between sowing dates and genotypes observed later stages for some growth parameters and for developmental stages, but the some was not continued in early stages. Hence the reflection was noticed in crop productivity. The interaction effect for biological yield, straw yield harvest index and for grain to straw ratio was significant.

Significantly maximum biological yield in DBW-16 under December 15 sown crop. Under January 3 sown crop genotype UP-2425 and DBW-16 produced almost equal biological yield.

In straw yield genotype DBW-16 produced at par to UP-2425 and PBW-373 under December 15 sown crop. Under January 3 sown crop all genotypes produced at par value to straw yield.

In grain to straw ratio genotype Raj-3765 recorded at par value to UP-2425 and Raj-3765 under December 15 sown corp. Under January 3 sown crop genotype DBW-16 recorded significantly higher grain to straw ratio.

In harvest index genotype Raj-3765 recorded significantly higher harvest index over PBW-373 over all other genotypes under December 15 sown crop. Under January 3 sown crop genotype DBW-16 recorded maximum harvest index.

5.4 Nutrient content and uptake

The uptake of nutrient element, its mobility and plant growth effect its concentration in plant tissue. The nutrient uptake and dry matter production during plant growth upto maturity are not a steady state process and therefore, concentration of different nutrients in plant varies depending upon the extent of difference between plant growth and nutrient absorption. Also the movement of nutrient elements within and between plant parts changes their concentration in different plant parts.

The concentration of nutrient elements in plants also varies with time of growth. Therefore, when sampling for plant analysis, the time of sampling as related to stage, plant parts and character of growth are important for interpreting plant analysis results. The variety of hybrid environmental factors such as soil moisture, temperature light intensity and quality and such other factors may also effect the nutrient value at any specific time of sampling. All these factors are important in standardization of plant analysis for practical purposes.

From the data presented in Table (13), it is clear that nitrogen content as well as their uptake was maximum under December 15 sown crop than January 03 sown crop. This might be due to increase supply of nutrients directly through wheat's prolific root system in December 15. And period of nutrient accumulation in Jan 3 sown crop was short. Similar results were also found by (Pandey *et al.* 1991). The interaction was non-significant.

Phosphorus content in grain and straw of wheat and uptake was maximum under December 15 sown crop and genotype PBW-373 (Table 14). This may be due to genetic heredity of that genotype.

Interaction effect of sowing dates and genotypes of phosphorus uptake in grain also due to genetic heredity of genotypes. Similar results were also found by (Hossain *et al.*, 1998).

The potassium content in grain and straw of wheat crop follow the same trend as nitrogen and phosphorus (Table 15). Similar results were also found by (Hossain *et al.* 1998).

Interaction effect of sowing dates and genotypes on potassium uptake in grain due to genetic heredity.

5.5 Protein content

The data presented in Table 18 protein content in grain was maximum in December 15 sown and genotype UP-2425. This might be due to genetic heredity of that genotype.

6 SUMMERY AND CONCLUSION

A field experiment was conducted during rabi season at 2004-2005 at the Crop Research Centre, (C.R.C.) G.B. pant University of Agriculture and Technology, Pantnagar to evaluate four wheat genotypes (DBW-16, PBW-373, UP-2425 and Raj 3765) under two dates of sowing (December 15 and January 03). The treatments were laid out in spilt plot design with dates of sowing as main plot and genotypes as sub plot with three replications. The important findings of the present investigation are summarized as follow:

1. Germination count at 15 DAS was significantly influenced by dates of sowing and genotypes. Maximum number of plantsm^{-2} was observed under Raj-3765 at sowing on December 15.
2. December 15 sowing resulted taller plants at most of the stages. Differences among genotypes were obtained at most of the stages.
3. December 15 sown crop resulted significantly higher number of shoots. Raj-3765 produced higher number of shoots than other genotypes at 30 DAS whereas UP-2425 produced higher number of shoots at 90 days stage and at maturity.
4. Maximum total dry matter accumulation at various growth stages was in December 15 sown crop. Significantly higher total dry matter accumulation was produced by Raj-3765 at 60 days stage over other genotypes.
5. The number of days taken to 50 per cent heading was decreased as the sowing were delayed from December 15 to January 3. Genotype DBW-16 took significantly more days for heading.
6. The number of days taken to maturity was decreased as the sowing were delayed from December 15 to January 03. Genotype UP-2425 and Raj-3765 matured almost in equal time.

7. Higher grain yield was recorded in December 15 sown crop. The highest grain yield was obtained from genotypes DBW-16 than all other genotypes.
8. December 15 sown crop recorded the highest straw and biological yield than January 3. PBW-373 produced higher straw yield. DBW-16 produced maximum biological yield.
9. Longer spikes were recorded under December 15 sown crop. UP-2425 produced longer spike than other genotypes.
10. The number of fertile and strile spiklets per spike was affected by sowing dates. Higher number of fertile spikelets per spike were recorded under genotype DBW-16.
11. Number of grain per spike was affected by sowing dates. Higher number of grain per spike were produced by genotype DBW-16.
12. Higher 1000-grain weight was recorded in December 15 sown crop and higher 1000-grain weight was obtained with genotype DBW-16.
13. Higher harvest index and grain to straw ratio were observed in December 15 sown crop and in genotype DBW-16.
14. December 15 sown crop showed higher per cent nitrogen, phosphorus and potassium content in grain and straw which was 1.65, 0.314 and 0.677 per cent in grain and 0.591, 0.095 and 1.75 per cent in straw, respectively.

15. Protein content was also higher in December 15 sown crop than January 3 i.e. 10.3 and 10.1 per cent in grain, respectively.

From the results obtained, it can be concluded that wheat crop sown on December 15 produced significantly higher grain yield (34.7 q ha^{-1}) than January 3 (28.3 q ha^{-1}) sown crop. Among the genotypes DBW-16 gave significantly higher grain yield than all other genotypes. Reduction in grain yield was 19.1% in very late January sown crop in comparison to December 15 sown crop.

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APPENDIX-I

Week wise meteorological weather data during crop season (Rabi-2004-2005)

JulianWeek	Temperature (^0C)		Relative humidity (%)		Rainfall (mm)	Sunshine (hrs)
	Max.	Min.	Max.	Min.		
40 (01-07, Oct.)	30.8	21.7	88	65	11.8	7.8
41 (08-14, Oct.)	29.8	19.0	89	57	73.2	7.2
42 (15-21, Oct.)	29.1	15.0	85	50	0.0	9.6
43 (22-28, Oct.)	29.1	12.8	83	49	0.0	8.6
44 (29-04, Nov.)	27.4	10.5	88	46	0.0	8.5
45 (05-11, Nov.)	27.4	11.1	84	41	0.0	8.7
46 (12-18, Nov.)	26.2	11.2	92	49	0.0	6.5
47 (19-25, Nov)	25.4	11.8	91	56	0.0	4.3
48 (26-02, Dec.)	25.4	10.7	92	45	0.0	6.2
49 (03-09. Dec.)	25.5	7.6	93	42	0.0	7.8
50 (10-16, Dec.)	26.6	9.0	94	48	0.0	6.7
51 (17-23, Dec.)	22.9	8.8	93	56	0.0	6.1
52 (24-31, Dec.)	16.7	8.5	94	64	0.0	2.3
01 (01-07, Jan.)	20.7	7.6	95	61	0.0	4.4
02 (08-14, Jan.)	18.6	3.9	96	62	0.0	6.0
03 (15-21, Jan.)	19.1	6.8	93	61	17.8	5.7
04 (22-28, Jan.)	16.9	8.7	94	64	18.0	1.8
05 (29-04, Feb.)	19.0	8.0	94	61	7.2	4.4
06 (05-11, Feb.)	21.4	10.8	90	54	26.2	4.5
07 (12-18, Feb.)	22.6	11.4	89	49	12.8	5.2
08 (19-25, Feb.)	23.5	8.3	89	49	3.4	8.0
09 (26-04, Feb.)	26.0	11.1	90	46	0.0	8.4
10 (05-11, Mar.)	27.5	12.9	92	43	16.6	6.4
11(12-18, Mar.)	28.3	14.8	88	50	0.0	9.4
12 (19-25, Mar.)	29.1	14.4	84	53	12.8	7.0
13 (26-01, Apr.)	31.4	13.2	82	30	0.0	10.3
14 (02-08, Apr.)	33.2	15.3	61	27	0.0	10.5
15 (09-15, Apr.)	34.1	15.0	70	24	0.0	8.3
16 (16-22, Apr.)	34.8	14.1	68	24	0.0	10.2
17 (23-29, Apr.)	37.1	20.4	63	18	0.0	9.2

APPENDIX-II

Analysis of variance for plant height (cm) at 30, 60, 90 days after sowing and at maturity

Source of variation	d.f.	Mean squares			
		Days after sowing			
		30	60	90	Maturity
Replication	2	12.481	3.331	12.953	0.203
Sowing dates	1	1.214	341.259*	143.078	472.604*
Error (a)	2	4.655	4.431	21.679	6.197
Genotypes	3	46.211**	556.736**	270.130**	84.451**
Sowing dates × genotypes	3	11.566	15.354	36.407**	28.423
Error (b)	12	4.871	6.250	5.276	11.437

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-III

Analysis of variance for shoot count m^{-2} row length at 30, 60, 90 days after sowing and at maturity

Source of variation	d.f.	Mean squares			
		Days after sowing			
		30	60	90	Maturity
Replication	2	205.000	207.25	28.000	1.000
Sowing dates	1	11008.000*	14652.000**	5890.660**	5310.160**
Error (a)	2	192.830	9.620	39.660	43.040
Genotypes	3	1142.910*	1075.160**	190.330*	200.500*
Sowing dates × genotypes	3	811.63	671.500**	220.700**	143.160*
Error (b)	12	262.000	91.020	34.880	39.100

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX V

Analysis of variance for days taken to 50 per cent heading, maturity and germination count m^{-2}

Source of variation	d.f.	Mean sum of squares		
		Days taken to		
		Plant stand at Germination m^{-2}	50 per cent heading	Maturity
Replication	2	266.53	0.500	0.017
Sowing dates	1	5192.02*	748.167**	962.667**
Error (a)	2	68.80	0.667	2.667
Genotypes	3	16721.92**	53.389**	19.000**
Sowing dates × genotypes	3	638.49*	2.056*	0.999
Error (b)	12	135.33	0.472	0.500

APPENDIX -IV

Analysis of variance for total dry matter accumulation at 30, 60, 90 days after sowing and at maturity

Source of variation	d.f.	Mean sum of squares			
		Days after sowing			
		30	60	90	Maturity
Replication	2	2839.6	99.500	153067.0	103125.0
Sowing dates	1	7935.213	17447.42**	262065.7	1249573.00**
Error (a)	2	2445.481	36.541	50163.6	6653.6
Genotypes	3	3828.329	16349.64**	68866.3	74393.5*
Sowing dates × genotypes	3	3547.17	14.416	1128.5	30757.5
Error (b)	12	3714.895	46.069	35224.3	16138.8

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-VI

Analysis of variance for biological grain and straw yield, harvest index and grain to straw ratio

Source of variation	d.f.	Mean sum of squares				
		Biological yield	Grain yield	Straw yield	Harvest index	Grain to straw ratio
Replication	2	8.492	2.466	5.646	279.069	21.162
Sowing dates	1	2478.604	460.248*	799.250*	266.632	32.647
Error (a)	2	9.276	1.897	3.775	2916.653	467.618
Genotypes	3	28.121**	10.084**	16.042*	772.238*	63.326*
Sowing dates × genotypes	3	31.421**	0.315	34.507**	10.222*	71.341*
Error (b)	12	2.177	1.277	3.145	176.377	14.083

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-VII

Analysis of variance for yield attributes

Source of variation	d.f.	No. of spike m^{-2}	Spike length cm.	No. of Fertile spikelets/spike	No. of Sterile spikelets/spike	No. of Grain/spike	1000 grain weight (g)
Replication	2	8248.750	0.083	1.717	0.108	1.167	4.248
Sowing dates	1	338.333**	0.511	10.009**	0.260	170.667**	17.516**
Error (a)	2	7140.708	0.165	1.163	0.083	1.166	0.036
Genotypes	3	2506.333	6.387**	1.707	0.592**	2.500**	79.685**
Sowing dates × genotypes	3	1144.833	0.051	1.611	0.235	5.444	4.384
Error (b)	12	8064.729	0.192	3.247	0.072	2.388	1.675

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-VIII

Analysis of variance for N, P and K concentration in grain and straw at maturity stage

Source of variation	d.f.	Mean sum of squares					
		N concentration		P concentration		K concentration	
		Grain	Straw	Grain	Straw	Grain	Straw
Replication	2	0.005	0.000005	0.0000020	0.00008	0.00079	0.000003
Sowing dates	1	0.0032**	0.00058**	0.00062	0.00022	0.033*	0.038**
Error (a)	2	0.00002	0.0000050	0.000034	0.000018	0.00079	0.0000012
Genotypes	3	0.063**	0.0291**	0.0040**	0.00066**	0.0331**	0.0085**
Sowing dates × genotypes	3	0.00016	0.0000005	0.0000005	0.000031	0.00014	0.00020
Error (b)	12	0.0004	0.000010	0.000010	0.000017	0.00026	0.00053

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-IX

Analysis of variance for N, P and K uptake (kg ha^{-1}) in grain and straw at maturity stage

Source of variation	d.f.	Mean sum of squares					
		N uptake		P uptake		K uptake	
		Grain	Straw	Grain	Straw	Grain	Straw
Replication	2	22.47	37.80	1.177	1.706	9.778	311.796
Sowing dates	1	769.53**	361.14*	34.75**	15.025*	260.57*	3710.16**
Error (a)	2	4.16	12.93	0.063	0.311	4.302	94.479*
Genotypes	3	119.50**	315.59**	7.478**	8.325**	62.73**	777.898*
Sowing dates × genotypes	3	40.10	33.04	2.212”	0.489	12.976*	231.611
Error (b)	12	17.12	9.76	0.532	0.229	2.172	76.232

* Significant at 5% level of significance
** Significant at 1% level of significance

APPENDIX-X

Analysis of variance for total uptake of N, P and K (kg ha^{-1}) and protein content in grain

Source of variation	d.f.	Mean sum of squares			
		Total uptake of N (kg ha^{-1})	Total uptake of P (kg ha^{-1})	Total uptake of K (kg ha^{-1})	Protein content
Replication	2	121.632	4.971	407.34	0.0251
Sowing dates	1	3950.80	97.08**	5983.71*	12.125**
Error (a)	2	260.854	0.393	97.921	0.0016
Genotypes	3	1482.846*	30.804**	1261.89**	2.439**
Sowing dates × genotypes	3	543.83	4.189	311.732	0.0047
Error (b)	12	266.678	1.289	92.28	0.0163

* Significant at 5% level of significance
** Significant at 1% level of significance

VITA

The author was born on the 24th April 1982 in Pantnagar district Udham Singh Nagar (Uttaranchal). He passed his High School and Intermediate examination from U.P. Board in the year 1997 and 1999, respectively. He received his B.Sc. (Ag.) honors degree form Amar Singh Post Graduate College Lakhaoti Bulandshahr, Under Choudhary Charan Singh University Meerut in the year 2003. There after he joined the centre of Advanced Studies, Department of Agronomy, G.B.P.U.A.&.T., Pantnagar, U.S. Nagar (Uttaranchal) in year 2003 for his Masters Degree with major in Agronomy. The author was recipient of Graduate Research Assistantship from Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, during his M.Sc. degree programme.

Sumit Kumar Yadav
House No. I/43 A 15
Lal Bagh, Pantnagar
U.S. Nagar (Uttaranchal)
☎ *05944-234116*
E-mail: sumitkumaryadav_2005@yahoo.com

ABSTRACT

Name	:	**Sumit Kumar Yadav**	Id. No.	:	**30721**
Semester	:	**First**	Year of admission	:	**2003-2004**
Degree	:	**M.Sc. (Ag.)**	Department	:	**Agronomy**
Thesis Title	:	**"RESPONSE OF NEW WHEAT GENOTYPE AT DIFFERENT DATES OF SOWING UNDER LATE SOWN IRRIGATED CONDITIONS".**			
Advisor	:	**Dr. R.D. Misra**			

A field experiment was conducted in D_3 plot of the Crop Research Centre, G.B. Pant Univ. of Agric. & Tech., Pantnagar during rabi season of 2004-2005 to study the effect of wheat genotypes, dates of sowing on growth, development, yield nutrient uptake and grain quality.

The soil of the experiment plot was silty loam in texture with higher organic matter. Neutral in reaction, high available phosphorus and medium in available potassium content. The experiment was laid out in split plot design with three replication. Keeping two dates of sowing in main plot (December 15, 2004 (D_1) and January 3, 2005 (D_2) and four genotype of wheat DBW-16 (V_1), PBW-373 (V_2), UP-2425 (V_3), and Raj-3765 (V_4) in sub plots.December 15 sown crop resulted higher germination at 15 DAS, taller plants at most of the stages, significantly higher number of shoots, maximum total dry matte accumulation at various stages of crop growth were obtained. Days taken to 50 per cent heading and days taken to maturity were significantly affected by dates of sowing. Higher grain yield and nutrient uptake were recorded in December 15 sown crop. Protein content was also higher in December 15 sown crop than January 3. Among genotype DBW-16 gave significantly higher grain yield than all other genotypes reduction in grain yield (19.4) and straw yield (21.7%) were recorded in very late sown crop (January 3) in comparison to December 15 sown crop.

(R.D. Misra)
Advisor

(Sumit Kumar Yadav)
Author