Optimum sowing date and fertilizer management for durum wheat genotype DWK 38 in mid-hills condition

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Abstract
Durum wheat is relatively new crop for Nepal and research on durum wheat were carried out only by Agriculture Botany Division of Nepal Agricultural Research Council (NARC). To find the optimum sowing time and fertilizer dose for mid-hills conditions of Nepal, an experiment was carried out in 2017/18 and 2018/19 at Agronomy Division Experimental farm in Khumlatar at an altitude of 1360 masl. The experimental design was factorial randomised complete block design. There were 3 fertilizer level and 4 sowing date constituting 12 treatment combinations. From the combined analysis over years, we found that plant height, days to heading, days to maturity, thousand grain weight and grain yield were found significnat in sowing date whereas number of tillers per square meter, straw yield and harvest index were significant in fertilizer doses**.** Combined analysis of both years yielded mean grain yield of 5.2 t/ha and thousand grain weight of 48.6 gm respectively. Precipitation during reproductive period (March-April) in 2017/18 contributed in higher grain yield than 2018/19. Optimum sowing date of durum wheat for khumaltar condition is no later than 26 November and optimum dose of fertilizer is 125:75:50 $N:P_2O_5:K_2O$ kg/ha.

Keywords: Durum, fertilizer, optimum, sowing date, yield

Introduction
Bread wheat (*Triticum aestivum* L.), commonly wheat, is widely grown throughout the world (Slafer, *et al.,* 1994). The global wheat production was 734045174 tons from harvested area of 214991888 ha (FAOSTAT, 2018).Wheat occupies 3rd position in terms of area and production in Nepal after paddy and maize. In 2018/19, area occupied by wheat was 703,992 ha and production was 2005665 mt (MoALD 2020). Grain yield of wheat was significantly influenced by sowing dates and cultivars (Fazal *et al.*, 2015). Wheat is sown in winter as it has its own definite requirement for temperature and light for emergence, growth and heading (Dabre *et al*., 1993). Too early sowing produces weak plants with poor root system as the temperature is above optimum. Temperature above optimum leads to irregular germination and the embryo frequently dies. Late sowing results in poor tillering and crop grow generally slow which get short growth period in the field (Sattar *et al.*, 2010). Timely sowing is important for obtaining high yield. Delay in sowing from 15 November to 15 December decreased grain yield by 32.6 % to 27.4 % (Virendar *et al.*, 2002).

Durum wheat (*Triticum turgidum* sp. *durum*) growing regions are the middle East, Southern Europe, North Africa, the former Soviet Union, North America and India. Worldwide, durum is grown in approximately in 13 million hectares (Boyacioglu, 2017) and with production of 30 million tonnes. The major durum producing countries in the world are Canada (>2 million ha), USA (>1 million ha), Mediterranean (particularly in Italy with >1 million ha), France, Spain and Greece each with > 500000 ha (Miedaner and Longin, 2012). Durum wheat has tremendous scope of production in plain areas of mid and far western regions of Nepal (ABD, 2014). Nepal has imported 417571 kg of durum wheat worth Rs 1,066,258,000 during 2018/19 (MOALD, 2020). Researches on durum wheat were carried outby National Plant Breeding and Genetics Research Centre (then Agriculture Botany Division) of NARC in coordination with Agriculture Research Directorate, Lumbini Province (then RARS Khajura) at Khajura, Banke for durum wheat improvement for mid and far western terai (ABD, 2014).The general recommended fertilizer dose for durum wheat is 120:60:60 $N:P_2O_5:K_2O$ kg/ha (ABD, 2015), wherever this is not site and variety specific. The research work on date of sowing and dose of fertilizer on

promising durum wheat genotypes is very limited. Therefore, this experiment was designed and conducted at National Agronomy Research Centre, Khumaltar to find out the optimum date of planting and optimum fertilizer dose for durum wheat genotype DWK 38.

Materials and Methods

The field experiments were conducted in the winter season of 2017 and 2018 in the experimental field of Agronomy division, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal. The site was geographically located at 85°10'E Longitude 27°39'N latitude and at 1360 masl altitude and the experiments were laid out in factorial randomized complete block design (RCBD) in three replications. The field was prepared using Mould Board plough and soil clods were broken with disc harrow. The plot size was 4m x 3m and row spacing was 25 cm. The three different fertilizer doses comprised as factor A (125:75:50, 150:75:50 and 175:75:50 $N:P_2O_5:K_2O$ kg/ha) and four sowing dates as Factor B (6^{th} Nov, 16^{th} Nov, 26^{th} Nov and 6^{th} Dec).The durum wheat genotype used was DWK 38 and seeds were manually sown in line at the rate of 120 kg per hectare. Half dose of nitrogen and full dose of phosphorus and potash was applied as basal dose and remaining nitrogen was top dressed at tillering and heading stage. Nitrogen was applied through urea, phosphorus through Di-ammonium phosphate (DAP), and potash through Muriate of Potash (MOP). All the recommended agronomic practices including irrigation, weeding and hoeing were carried out for all the treatments. Ten random plants from each plot were selected for recording plant height and spike length. $1m^2$ quadrate was used to estimate tillers/m^2, 10 randomly selected spikes were taken to estimate number of grains/spike and 1000 grain weight. In case of grain yield and straw yield estimation, net harvested area of 8 m^2 was used. The data obtained were analyzed using the software STAR and grand mean, coefficient of variation (CV %) and least significant difference of mean (LSD) were calculated.

Meteorological data

The meteorological data were obtained from the meteorological station at Agronomy division. The mean maximum and minimum temperature in 2017/18 were 23.2 °C and 8.40 °C respectively in crop growing period. Total rainfall recorded was 181.6 mm and numbers of rainy days was 40 days. In 2017/18, April received highest volume of rainfall which helps in reproductive growth of crop. Similarly, the mean maximum and minimum temperature in 2018/19 were 22.2 °C and 8.0 °C respectively. Total rainfall recorded was 310.3 mm and number of rainy days was 41. May received highest volume of rainfall of 120.9 mm in 5 days which adversely affects in yield and yield parameters.

Results and Discussion

The result of the experiments shows that data on plant height ranged from 94.8 to 98.9 cm among different fertilizer doses and 94.3 to 100.8 cm among different sowing dates with mean plant height 97.2 cm in 2017. It shows that fertilizer and even sowing date does not impact on plant height in 2017, however, plant height decreased after 16 November (table 2). Similarly, plant height ranged from 97.5 to 101.9 cm among different fertilizer doses and 94.9 to 104.0 cm among different sowing dates in 2018. Plant height was significantly different among different sowing dates with maximum plant height in 26 Nov (104.0 cm) and minimum in 6 Dec (94.9 cm) and mean plant height 100.3 cm in 2018 (table 3). Spike length ranged from 7.6 to 7.8 cm among different fertilizer doses and 7.2 to 8.0 cm among different sowing dates in 2017 which are not significantly different within the groups. The mean spike length in 2017 was 7.7 cm. In 2018, spike length ranged from 10.5 to 12.1 cm among fertilizer doses and 10.3 cm to 12.3 cm among different sowing dates which are not significantly different within the groups. The mean spike length in 2018 was11.0 cm. Days to 50 % heading in durum wheat ranged from 115.9 to 117.1 days among different fertilizer doses which was not significantly different within the group. Days to 50% heading ranged from 111.5 to 123.3 days with thelowest for late sown wheat and the highest value for early sown wheat. Days to 50% heading in sowing date was significantly different within the group where mean days to 50% heading was116.4 days in 2017. Similarly in 2018, days to heading ranged from 126 to 126.5 days among different fertilizer doses which was not significantly different within the group

while days to heading ranged from 116.4 to 134.6 days among different sowing dates which was significant among sowing dates. The mean 50% days to heading in 2018 was 126.2 days.

No. of grains per spike, grain yield and straw yield were found non-significant both in fertilizer doses and date of sowing while days to 90% maturity, tillers per m^2 and thousand grain weight in date of sowing and harvest index in fertilizer doses were found significantly different (however tillers per m^2 and thousand grain weight in fertilizer doses and harvest index in date of sowing were found non-significant) in 2017. Days to 90 % maturity ranged from 165.3 to 171.5 days in fertilizer level and 159.3 to 183.6 days in sowing days with mean maturity of 169.2 days. Number of tillers per m^2 ranged from 374.1 to 455.5 in fertilizer doses and 334.1 to 514.1 in sowing dates. Highest no. of tillers both in fertilizer doses and sowing dates contributed in straw yield rather than grain yield. The mean value for tillers was 427.7 in 2017. No. of grains per spike ranged from 48.4 to 49.9 in fertilizer dose and 45.3 to 53.5 with mean value of 49.2 in 2017. Thousand grain weight ranged from 50.1 to 51.4 g in fertilizer doses and 46.3 to 55.7 gm with mean test weight 50.9 g in 2017. Grain yield in fertilizer doses ranged from 5.67 to 6.43 t/ha and 5.82 to 6.06 t/ha in sowing dates in 2017 with mean grain yield of 5.98 t/ha. Straw yield ranged from 8.1 to 11.15 t/ha in fertilizer level and 8.3 to 10.7 t/ha in sowing dates with mean straw yield of 9.4 t/ha in 2017. Harvest index ranged from 0.35 to 0.46 in fertilizer level and 0.35 to 0.44 in sowing dates with mean harvest index of 0.40 in 2017.

Table 1. Yield and yield attributing traits of durum wheat trial in 2017/18

Treatments	PH	SL	DH	DM	Tillers	Grains	TGW	GY	SY	HI
Fertilizer dose (A) ($N:P_2O_5:K_2O$ kg/ha)										
125:75:50	97.9	7.6	116.1	170.7	374.1	49.9	51.4	6.4	8.1	0.46
150:75:50	94.8	7.6	115.9	170.3	453.6	49.4	51.2	5.8	9.0	0.40
175:75:50	98.9	7.8	117.1	171.5	455.5	48.4	50.1	5.7	11.1	0.35
LSD (P<0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.07
Sowing date (B)										
6Nov	98.9	7.9	123.3	183.6	334.1	53.5	55.7	6.1	9.4	0.44
16 Nov	100.8	8.0	115.4	174.7	399.6	52.2	54.2	6.0	8.3	0.43
26 Nov	95.0	7.6	115.1	165.9	463.1	45.7	47.5	6.0	9.3	0.40
6 Dec	94.3	7.2	111.6	159.3	514.1	45.3	46.3	5.8	10.7	0.35
LSD (P<0.05)	ns	ns	2.5	2.3	97.4	ns	3.4	ns	ns	ns
A*B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	5.7	8.8	2.2	1.4	23.3	18.8	6.8	18.1	34.8	21.4
Grand Mean	97.2	7.7	116.4	170.9	427.7	49.2	50.9	6.0	9.4	0.40

Note: *PH: Plant height (cm), SL: spike length (cm), DH: days to 50% heading, DM: days to 90% maturity, tillers: No. of tillers per m^2, Grains: No. of grains per spike, TGW: thousand grain weight (g), GY: grain yield (t/ha), SY: Straw yield (t/ha), HI: harvest index*

In winter season 2018, plant height of durum wheat ranged from 97.5 to 101.9 cm in fertilizer doses and 94.9 to 104.0 cm in sowing dates. Plant height was significantly different in different sowing dates. The mean plant height was 100.3 cm. Spike length ranged from 10.5 to 12.1cm in different fertilizer doses and 10.3 to 12.3cm in different sowing dates. The values were not significantly different in both fertilizer dose and sowing date. The mean spike length was 11.02 cm. Similarly, days to 50% heading ranged from 126 to 126.5 days in fertilizer doses and 116.4 to 134.6 days in sowing days which was significantly different. Early sown durum wheat takes longer period for heading while late sown wheat are earlier in heading. Day to 50% heading mean was 126.22 days. Days to 90% maturity ranged from 168.92 to 170 days in

fertilizer doses while it ranged from 156.2 to 179.8 days in sowing dates which were significantly different. Like heading, early sown wheat matured late and late sown wheat matured early. The mean days to 90% maturity was 169.3 days. Number of tillers per m^2 ranged from 306.1 to 370.5 in fertilizer doses which were significantly different with maximum number of tillers (370.5) in highest fertilizer dose (175:75:50 N:P_2O_5:K_2O kg/ha). The tillers numbers ranged from 245.4 to 377.4 in sowing date which was significantly different among different sowing dates. Minimum tillers were found in late sown wheat. The mean tillersnumber per m^2 was 335.2. No. of grains per spike ranged from 42.5 to 45.1 in fertilizer doses while it ranged from 40.1 to 50.4 in sowing date which was significantly different among sowing dates. Grains per spike was found maximum (50.4) in late sown wheat. The mean no. of grains per spike was 43.7. Thousand grain weight (test weight) ranged from 44.8 to 47.7 g in fertilizer doses which was significantly different while test weight ranged from 43.9 to 47.9 g in different sowing dates which was also significantly different. The mean test weight was 46.3 cm.

Grain yield ranged from 4.09 to 4.85 t/ha in difzferent fertilizer doses which was significantly different. Highest fertilizer dose (175:75:50N:P_2O_5:K_2O kg/ha) gave highest grain yield of 4.85 t/ha.Timely precipitation during growing season could have contributed in optimization of fertilizer which ultimately foster grain yield. Similarly, grain yield ranged from 3.37 to 5.28 t/ha in sowing date which was also significantly different. Maximum grain yield was obtained from 26 Nov (early planting) and minimum from 6 Dec (late planting). The mean grain yield was 4.49 t/ha. Similarly, straw yield ranged from 6.1 to 7.4 t/ha in fertilizer doses while it ranged from 4.1 to 7.7 t/ha in sowing dates. The yield is significantly different in sowing dates with minimum yield in 6th Dec and maximum yield in 6th Nov. The mean straw yield was 6.68 t/ha. The harvest index value in different fertilizer doses ranged from 0.40 to 0.42 while the value ranged from 0.38 to 0.44 in sowing dates (Table 2). The index was neither significant in fertilizer dose nor in sowing date. The mean harvest index value was 0.41.

Table 2. Yield and yield attributing traits of durum wheat trial in 2018/19

Treatments	PH	SL	DH	DM	Tillers	Grains	TGW	GY	SY	HI
Fertilizer dose (A) (N:P_2O_5:K_2O kg/ha)										
125:75:50	97.5	10.5	126.2	168.9	328.9	42.5	47.7	4.1	6.1	0.41
150:75:50	101.5	10.5	126.0	170.0	306.1	43.5	44.8	4.5	6.5	0.42
175:75:50	102.0	10.4	126.5	169.0	370.5	45.1	46.3	4.9	7.4	0.40
LSD (P<0.05)	ns	ns	ns	ns	47.0	ns	3.3	0.6	ns	ns
Sowing date (B)										
6Nov	100.5	10.3	134.6	179.8	358.1	40.9	47.8	4.5	7.7	0.38
16 Nov	102.0	10.1	128.9	175.0	359.7	40.1	47.9	4.8	7.2	0.40
26 Nov	104.0	10.5	125.0	166.2	377.4	43.4	45.5	5.3	7.6	0.41
6 Dec	94.9	11.0	116.4	156.2	245.4	50.4	43.9	3.4	4.1	0.44
LSD (P<0.05)	4.9	0.6	2.9	3.9	54.2	6.2	3.3	0.7	1.5	ns
A*B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	5.0	5.8	2.4	2.3	16.6	14.6	4.2	14.9	22.8	13.3
Grand Mean	100.3	10.5	126.2	169.3	335.2	43.7	46.3	4.5	6.7	0.4

Note: *PH: Plant height (cm), SL: spike length (cm), DH: days to 50% heading, DM: days to 90% maturity, tillers: No. of tillers per m^2, Grains: No. of grains per spike, TGW: thousand grain weight (g), GY: grain yield (t/ha), SY: Straw yield (t/ha), HI: harvest index*

Plant height of durum wheat has exhibited significant difference in different sowing dates in 2018 while there was no significant difference in 2017 in sowing dates. Plant height was not significant in both years over fertilizer doses. Similarly, spike length was not significant for fertilizer doses and sowing dates in

both years. Days to heading and days to maturity were higher in early sown wheat as compared to late sown wheat in both years. In 2017, days to heading were earlier than 2018 but maturity date was later than 2018 in every date. Effect of fertilizer doses was not found significant in both years. Tillers number was found significant for both fertilizer doses and sowing dates in 2018 and only for sowing date in 2017. Although tillers number was more in 2017 for fertilizer dose and sowing date, the result was not significant within sowing date and fertilizer dose. Number of grains per spike was found significant for sowing date in 2018 which may be due to less plant population. Thousand grain weight was found significant for different sowing dates in both years and fertilizer doses in 2018 however mean thousand grain weight was higher in 2017 (50.9 g) compared to 2018 (46.3 g). Grain yield was found non-significant in 2017 and significant in 2018 for both factors, however, mean grain yield was higher in 2017 (5.98 t/ha) than 2018 (4.49 t/ha).Straw yield was only significant in sowing date in 2018. Like grain yield, mean straw yield was also higher in 2017 (9.39 t/ha) than 2018 (6.68 t/ha). Although, mean harvest index was higher in 2018 compared to 2017, there was no significant difference in 2018. Harvest index was significant difference in fertilizer doses in 2017. Fertilizer dose 125:75:50 N: P_2O_5:K_2O kg/ha yielded highest HI (0.46) and lowest by 175:75:50 N: P_2O_5:K_2O kg/ha (0.35). Fertilizer dose was found non-significant for almost all traits in both years.

Table 3. Combined analysis of yield and yield attributing traits of durum wheat trial over 2017/18 and 2018/19

Treatments	PH	SL	DH	DM	Tillers	Grains	TGW	GY	SY	HI
Fertilizer dose (A) (N:P_2O_5:K_2O kg/ha)										
125:75:50	97.7	9.1	121.1	169.8	351.5	47.8	49.6	5.3	7.1	0.43
150:75:50	98.2	9.0	121.0	167.6	379.8	47.2	48.0	5.2	7.8	0.41
175:75:50	100.5	9.1	121.8	170.3	413.0	47.0	48.2	5.3	9.2	0.38
LSD (P<0.05)	ns	ns	ns	ns	46.9	ns	ns	ns	1.5	0.04
Sowing date (B)										
6 Nov	99.7	9.1	128.9	181.7	346.1	50.1	51.8	5.3	8.6	0.41
16 Nov	101.4	9.1	122.2	174.8	379.6	48.2	51.1	5.4	7.7	0.41
26 Nov	99.5	9.0	120.1	166.1	420.3	45.5	46.5	5.6	8.4	0.40
6 Dec	94.6	9.1	114.0	157.8	379.8	45.6	45.1	4.6	7.0	0.40
LSD (P<0.05)	3.5	ns	2.6	2.2	ns	ns	4.6	0.8	ns	ns
A*B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	5.3	7.1	2.3	1.9	21.1	17.1	5.7	17.2	31.	17.8
Grand Mean	98.8	9.1	121.3	170.1	381.4	46.5	48.6	5.2	8.0	0.41

Note: *PH: Plant height (cm), SL: spike length (cm), DH: days to 50% heading, DM: days to 90% maturity, tillers: No. of tillers per m^2, Grains: No. of grains per spike, TGW: thousand grain weight (g), GY: grain yield (t/ha), SY: Straw yield (t/ha), HI: harvest index*

After combined analysis of data over two years, results for different parameters were obtained. Plant height was found non significant for fertilizer dose however it was significant for date of sowing with mean plant height 98.8 cm. Late sown wheat had shorter plant height than earlier dates. Late sown wheat had shorter height due to shorter growing period. Early sown crop had enjoyed longer growing period with plenty of temperature and solar radiation which resulted in taller plants. Similar results were also reported by Shahzad *et al.*, (2002) and Anwar *et al.*, (2015). On other side spike length was found non-significant for both fertilizer and sowing date with mean spike length 9.1cm. Days to heading and days to maturity were significant for date only and mean were 121.3 days and 170.1 days respectively. Early sowing took longer period for heading and maturity. Numbers of tillers per m^2 were found significant in

fertilizer doses and mean value was 381.4. Highest fertilizer dose contributed highest tillers. Number of grains per spike were non-significant in both fertilizer dose and date where mean number of grains per spike was 46.5. Highest thousand grain weight was recorded in early planting. Early sowing resulted in better development of seeds due to longer growing periods whereas decreased in thousand grain weight in delayed sowing was also reported by Spink *et al.,* (2000) and Anwar *et al.,* (2015). Early sowing date at Nov 26 gave highest grain yield (5.6 t/ha) while late sowing at 6 Dec yielded lowest yield (4.6 t/ha) where mean value of thousand grain weight and grain yield were 48.6 g and 5.2 t/ha respectively. Highest fertilizer dose (175:75:50 N: P_2O_5:K_2O kg/ha) gave highest straw yield (9.2 t/ha) and lowest harvest index (0.38) which may be due to highest number of tillers per m^2 (413). Harvest index had inverse relationship with straw yield. The highest harvest index (0.43) was recorded in the lowest fertilizer dose (125:75:50 N: P_2O_5:K_2O kg/ha). Mean straw yield and mean harvest index were 8.0 t/ha and 0.41 respectively.

Conclusion

From the two years experiment data, durum wheat sown by 26th November gave maximum grain yield and later from this date, grain yield decreases by 100 kg/ha/day in Khumaltar condition .Sowing date had significant result on growth and yield attributing traits like plant height, days to heading, days to maturity, thousand grain weight and grain yield whilefertilizer dose had significant result in number of tillers per m^2, straw yield and harvest index**.** Fertilizer dose was found significant for number of tillers per m^2 but not for yield. This may be due to less source sink conversion because of which straw yield was highest in highest fertilizer level. From this experiment, we conclude that fertilizer dose of 125:75:50 N:P_2O_5:K_2O kg/ha is optimum for growth and yield of durum wheat in Khumaltar condition.

Acknowledgements

The authors like to extend sincere their thanks to NARC for funding the project. Special thanks go to Mr. Subindra Balami for timely conduction of field activities and helps in data recording. Timely guidance from Division Chief and seniors are highly acknowledged.

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