EFFECT OF DIFFERENT SEEDING RATES ON YIELD ATTRIBUTES OF DUAL-PURPOSE WHEAT

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ABSTRACT

Growing more food is the need of the day for ever increasing populations of human and animals. Moreover, it is challenge for the agriculture scientists to increase food production by increasing yields . To increase wheat production by increasing yields per hectare an experiment was conducted at the Agricultural Research Institute, Dera Ismail Khan. In this experiment the performance of dual-purpose wheat under varying seeding rates was investigated. Five seed rate treatments (100, 140, 180 and 220 kg ha^{-1}) of wheat variety Zam-04 were planted as cut for forage and grain in one block and as grains (no cut) in another block. The data indicated that increasing seed rate, increased was observed in number of tillers m^{-2} (287), number of spike m^{-2} (281), biological yield (11690 kg ha^{-1}), fresh and dry forage yield (3961 and 832.6 kg ha^{-1}) and grain yield (4741 kg ha^{-1}) by increasing seeding densities while the reverse was observed for days to heading (122.5), number of grains spike^{-1} (58.9) and spike length (11.9cm). These parameters were higher in lower seed rate (100 kg ha^{-1}). Cutting wheat at 60 days after sowing negatively affected the number of tillers m^{-2} (241), 1000-grain weight (38.65g) and biological yield (10252 kg ha^{-1}). Number of grains spike^{-1}, spike length, number of spikes m^{-2}, plant height and grain yield were non-significantly affected by cutting treatments. Significant interaction of seeding rate x cutting was recorded for number of days to heading and number of spikes m^{-2}. Hence it is concluded that dual-purpose wheat system, with 140 kg ha^{-1} seed rate, had higher ability of providing fodder in cold winter though it produced less grain yield as compared to no cut plots.

INTRODUCTION

Wheat (Triticum aestivum L.) being world first ranked grain crop is the mainstay of the agricultural economy of Pakistan and thus occupies a key role in agricultural policies (Ali *et al.*, 2007; Shuaib *et al.*, 2007). Its contribution in value addition to agriculture is about 14% with 3.1% to GDP (Anonymous, 2010). Wheat is generally cultivated for only grain production, but in countries like Argentina (Arzadun *et al.*, 2006), Australia, Morocco (Rodriguez *et al.*, 1990), Syria and Uruguay (Epplin *et al.*, 2000), it is commonly grown both as fodder and grain purposes crop for livestock due to its palatability, higher crude protein and digestibility compared to fodder crops (Hossain *et al.*, 2003; Krenzer, 2000). In Pakistan (during 2009-10) wheat was cultivated on an area of 9.04 million hectares with its total production of 23.86 million tons with average yield of 2639 kg ha^{-1}. However, during the same year, in Khyber Pakhtunkhwa, it was grown on an area of 0.78 m ha producing 1.2 m tones with average yield of 1856 kg ha^{-1} (MINFAL, 2010). Dual-purpose wheat means getting fodder by giving a cut before 1st node formation (jointing or stem elongation stage) as well as grain at maturity from the same crop of wheat. Epplin *et al.* (2000) reported dual-purpose wheat cultivation in Argentina, Austria, Morocco, Pakistan, Syria and Uruguay. Quality fodder availability during winter is critical constraint in improving livestock production in the country (Khan *et al.*, 2003). Due to ever increasing human need for food grains, only limited cultivated land can be allocated to fodder production. Furthermore, low yield per unit area is also one of the constraints in the availability of fodder supply. Thus in order to reduce competition between fodder and grain crops for area due to the limited arable land, there is imperative need for the development of a technology of dual purpose cropping system such as wheat.

Plant density is one of the major factors determining the ability of the crop to capture resources. It is of particular importance in wheat production as it is under the farmer's control in most cropping systems (Satorre, 1999). Seeding rate and row spacing strongly influence the use of environmental resources as they change the relative importance of interplant and intra plant competition for light, water and nutrients during crop development. In case of dual-purpose wheat, higher seeding rates i.e. higher number of plants compensates for the loss of tillers due to cut i.e. few tillers fail to regrow after cut, as compared to low seed rates. Seeding rate is an equally important practice in the management of wheat productivity. Under rain-fed conditions in Nebraska, an increase in seeding rate resulted in higher mean plant population, plant height, grain yield, and grain volume

weight among wheat genotypes (Geleta *et al.*, 2002). Freebairn, (2005) reported that high sowing rates normally have no negative effect on grain yield or quality.

Keeping in view the ever increasing demand of both grain and fodder production in the country, the present experiment was conducted with the aims to determine the optimal planting density suitable for dual purpose system with greater re-growth potential and to compare the grain quality parameters and economic returns of both the systems.

MATERIALS AND METHODS

The experiment was laid out in a randomized complete block design (factorial) using four seeding rates viz. 100, 140, 180, 220 kg ha^{-1} as Factor-A and cutting (No cut vs. Cut) as Factor-B at the Agricultural Research Institute, Dera Ismail Khan, KPK, Pakistan. The net plot size was 1.8 m x5 m having 6 rows, 5 m long and 30 cm apart. Zam-04 (a long duration, tall variety with good tillering ability) was used as test variety. Fertilizers were applied at the rate of 150-120-90 NPK kg ha^{-1} in the form of Urea, Triple Super Phosphate and Sulpahte of Potash, respectively. Half of nitrogen and all phosphorous and potash were applied at the time of sowing while remaining nitrogen was applied with first irrigation. A cut (C1) was given to half of the treatments 60 days after sowing to compare with rest of no cut (C0) treatments. Weedicide Buctril Super and Puma Super were applied at the rate of 750 ml ha^{-1} after first irrigation for the control of broad and narrow leaved weeds. The soil of the experimental site was clay loam having pH 8.82 and < 1% organic matter. The available P and K in soil were---- ----------. The available P was determined by ----------method and available K was determined by -------method. The metrological data of the test site revealed the maximum temperature in April was 37C^{0} and minimum of 5C^{0} in December and January (Table 1). Data on various parameters were compiled and analyzed statistically (Steel and Torrie, 1997) using MSTATC computer software. Least significant difference (LSD) test was used to check the difference among treatment means.

Table 1. *Average monthly and seasonal weather data at the Agricultural Research Institute, Dera Ismail Khan, during 2009-2010.*

Month	Temperature (^{0}C)		Relative Humidity		Rainfall (mm)
	Max.	Min.	0800 Hrs.	1400 Hrs.	
October	33	16	82	57	13
November	25	10	80	55	--
December	22	5	81	63	--
January	16	5	88	76	9.2
February	22	8	76	58	1.1
March	30	15	63	63	2.2
April	37	19	74	45	--

RESULTS AND DISCUSSION

Fresh Forage Yield (kg ha^{-1})

Winter wheat canopy, associated plant physiology and its modeling (Bindraban, 1999; Heidmann *et al.*, 2000) helps to precise growth and development, but canopy depends on air temperature and its humidity (Kostrej *et al.*, 1996). Fresh forage yield was recorded by cutting wheat crop (60 days after sowing) just before it reached the first hollow stem stage (FHS). Different seeding rates had significantly (p<0.05) affected fresh forage yield of wheat (Table 2). Maximum and statistically at par fresh forage yield of 3961 and 3642 kg ha^{-1} was recorded with seed rate of 220 kg ha^{-1} and 180 kg seed ha^{-1} respectively. The lowest fresh forge yield (2144kg ha^{-1}) was produced by normal seed rate of 100 kg ha^{-1}. Maximum forage yield obtained with the highest planting density was probably due to higher number of leaves and leaf area index. In the present study, leaf area index has shown a direct correlation with the forge yield because the maximum LAI was recorded with the highest seeding density of 220kg seed ha^{-1} while the minimum LAI was obtained with the normal seed rate of 100 kg ha^{-1} data not shown. Similar results were also reported by Larson *et al.* (2005) who found that forage yield increased with increasing seeding rates. Krenzer *et al.* (2003) reported increase in forage yield with increasing seeding rates. Bonachela *et al.* (1995) obtained higher forage production from longer crop duration before clipping date (with higher leaf numbers on the main stem and tiller numbers per plant) or higher plant density. These results are in contradiction to Sulieman (2010).

Table 2. *Effect of seeding rates on fresh and dry forage yield (kg ha^{-1}) of dual-purpose wheat.*

Seeding rates (kg ha^{-1})	Fresh forage yield (kg ha^{-1})	Dry forage yield (kg ha^{-1})
100	2144 c	554.4 c
140	2886 b	702.5 b
180	3642 a	736.9 b
220	3961 a	832.7 a

LSD$_{0.05}$ (Fresh forage) = 699.1　　　　　LSD$_{0.05}$ (Dry forage) = 84.25

Means followed by different letter(s) in a column are significant at 5% level of probability.

Dry Forage Yield (kg ha^{-1})

Plant growth is the increase in dry weight overtime, mainly as a consequence of photosynthesis. Weight increases are often determined by harvesting the entire plant or part of interest and weighing it rapidly, before too much water evaporates from it. Because of problems arising from variable water contents, many people, particularly those in crop productivity, prefer to use increase in dry weight of a plant or plant parts as a measure of its growth. The data given in Table-2 showed that seeding rates had a significant (p<0.05) effect on dry forage yield. Maximum dry forage yield of 832.7 kg ha^{-1} was produced with the highest seeding rate of 220 kg ha^{-1} while normal seed rate of 100 kg ha^{-1} produced minimum dry forage yield of 554.4 kg ha^{-1}. Previous research findings revealed that higher seeding rates generally increased dry matter production especially in early grazing (Freebairn, 2005). Our research findings are augmented by the findings of Richards *et al.* (2002). Tompkins *et al.* (1991) also found that pre-anthesis biomass was higher with high seeding rates.

Number of Tillers m^{-2}

The economic yield of most of the cereals is determined by number of tillers. In this experiment the Number of tillers were significantly (p<0.05) affected by cutting and seed rate treatments (Table 3. Higher tillers were counted in no cut plots (266.1) as compared to cut plots (241.2 tillers m^{-2}). The significant reduction of C1 was probably due to the decapitation stress (reduced leaf area) that resulted in less tillers regrowth. Similarly, higher and statistically at par number of tillers m^{-2}(287.6 and 267.1) was recorded at seed rate of 220 kg and 180 kg ha^{-1}, respectively. Fewer tillers were counted by sowing wheat at the rate of 100 kg ha^{-1}. Tillers play an important role to compensate the difference in number of plants, partially or totally after crop establishment and may allow crop recovery from early frost (Acevedo *et al.*, 1998). Baloch *et al.* (2010) demonstrated that different seed rates significantly increased the number of tillers, wherein, the use of 200 kg seed ha^{-1} produced higher number of tillers closely followed by 150 kg seed ha^{-1}. The interaction of cutting treatments and seeding rates was non-significant; however, maximum tillers (300.20 m^{-2}) were recorded with 220 kg seed ha^{-1} in C0 treatment followed by 276.5 tillers m^{-2} in the same treatment with 180 kg seed ha^{-1}. .

Table 3. *Number of tillers m^{-2}, days to heading and grains spike^{-1} of DP wheat as affected by sowing date and seed rate.*

Seed rate (kg ha^{-1})	No of tillers (m^{-2})	Days to heading	Grains spike^{-1}
100	228.6 b	122.5 a	58.9 a
140	231.9 b	121.1 b	53.8 b
180	267.1 a	120.1 c	51.8 b
220	287.3 a	119.0 d	48.4 b
LSD$_{(0.05)}$	20.48	0.446	5.5
Cutting treatments			
No Cut (C0)	266.1 a	115.9 b	53.9
Cut (60 DAS)	241.2 b	125.5 a	52.1
LSD $_{(0.05)}$	14.18	0.63	Ns
Interactions	**Significance level$_{(0.05)}$**		
Seed rate (SR) x Cutting (C)	Ns	Fig (1)	Ns

Means of the same category followed by different letters are significantly different from each other.
* = significant at 5% level of probability
Ns = non significant at 5% level of probability

Days to Heading

Data regarding days to heading as affected by cutting and seed rate treatments are present in table3. The effect of all treatments was found significant. Cutting of wheat after 60 days of sowing took more days to heading (125.5) as compared to no cut plots (115.9). The convincingly delay in heading due to cutting might be attributed to the artificial stress imposed by removing the above-ground vegetative portion which took more time to reach to reproductive stage. Regarding seeding rates, higher number of days to heading was recorded by the lowest seed rate of 100 kg, followed by 140 kg seed ha^{-1} (121.1) while minimum number of days to heading (119.0) was noted in the highest seed rate of 220 kg ha^{-1}. Maximum number of days to heading by low seed rate might be attributed to the availability of more nutrients for relatively less number of plants (luxurious consumption of nutrients) as compared to high seed rate, where the same amount of nutrients was available for more than double number of plants. The interaction between seeding rates and cutting also showed significant (p<0.05) variations. The use of normal seed rate, being administered by a cut, took maximum days to heading (126.5) and was statistically at par with 140 kg seed ha^{-1} taking 126 days to heading, while minimum days to heading (114.3) was noted in no cut treatment with the highest seed rate of 220 kg ha^{-1}. Maximum days to

heading in cut treatment with the lowest seed rate might be due to the presence of comparatively less number of plants in per unit[-1] area field which received optimum amount of nutrients and thereby prolonged the period to switch over from vegetative to reproductive phase.

Number of Grains Spike[-1]

Many factors affect grains spike[-1] such as genotype, class of wheat (winter versus spring), cultural practices used (seeding rates, planting dates and soil fertility etc) and growing conditions (air and soil temp, soil water status). SPU (spike per unit area) and KPS (kernel per spike) generally are the most important determinants of grain yield (Shah *et al.*, 1994). The data given in Table-3 showed that there were non-significant ($p < 0.05$) variations in cut (C1) and no-cut (C0) treatments for number of grains spike[-1]. However, maximum number of grains spike[-1] (53.9) was recorded in C0 as compared to 52.1 grains spike[-1] produced in C1 treatment. Number of grains spike[-1] was significantly ($p < 0.05$) affected by seeding rates. Maximum grains (58.93) were produced by normal seed rate of 100 kg ha^{-1}. Hussain *et al.* (2001) obtained higher number of grains with the lowest seeding rate (80 kg ha^{-1}) which they attributed to more light penetration through plant canopy. Whaley *et al.* (2000) found that number of kernels spike[-1] increased by 50% in wheat plants when crop density decreased. Our results are further strengthened by Kilic *et al.* (2010) who noted a consistent decrease in number of grains spike[-1] with increasing seed rate. The interaction of cutting treatments and seeding rates was non-significant ($p < 0.05$). Seeding rate of 100kg ha^{-1} in C0 treatment produced higher number of grains spike[-1] (60.03) than C1 treatment (57.84 grains spike[-1]). Number of grains spike[-1] was lowest (47.4) in C1 treatment with 220kg seed ha^{-1}. Kernel weight does exert an influence on grain yield, however, experiments have demonstrated that its influence is generally smaller than those of spike unit area[-1] or kernel spike[-1] (Shah *et al.*, 1994).

Spike Length (cm)

Length of spike plays a vital role in wheat towards the grains spike[-1] and finally the yield (Shahzad *et al.*, 2007). The data indicated that spike length was non-significantly ($p < 0.05$) affected by cutting treatments while significant differences were noted for seeding rates (Table 4). Maximum spike length (11.99 cm) was attained when 100 kg seed ha^{-1} was used while other seeding rates (140, 180 and 220 kg ha^{-1}) produced statistically at par spike length of 11.25, 10.75 and 10.56 cm, respectively. Maximum spike length by lowest seed rate was possibly due to optimum availability of nutrients that enabled wheat plants to effectively carryout photosynthesis and hence more assimilate translocation occurred which ultimately increased the spike length. The interaction showed that spike length was non-significantly ($p < 0.05$) affected by cutting treatments and seeding rates. Seeding rate of 100 kg ha^{-1} in C0 treatment produced maximum spike length of 12.05 cm than the C1 treatment having spike length of 11.94 cm with the same seed rate. Minimum spike length (10.35cm) was recorded in C1 treatment with 220 kg ha^{-1}.

Table 4. *Spike length (cm), Number of spikes m[-2], 1000 grain weight (g) of DP wheat as affected by sowing date and seed rate.*

Seed rate (kg ha^{-1})	Spike length (cm)	Number of spikes (m[-2])	1000-grain weight(g)
100	11.9 a	209.4 c	40.9
140	11.2 b	252.1 b	39.74
180	10.7 b	281.8 a	39.78
220	10.5 b	270.4 a	40.18
LSD(0.05)	0.706	10.19	Ns
Cutting treatments			
No Cut (C0)	11.3	254.1a	41.65 a
Cut (60 DAS)	11.0	252.6b	38.65 b
LSD (0.05)	Ns	0.63	1.047
Interactions	Significance level(0.05)		
Seed rate (SR) x Cutting (C)	Ns	Fig (2)	Ns

Means of the same category followed by different letters are significantly different from each other.
* = significant at 5% level of probability
Ns = non significant at 5% level of probability

Number of Spikes (m[-2])

Spike acts as a major sink for dry matter accumulation (Demotes *et al.*, 2001). Mean values indicated that cutting had non-significant ($p < 0.05$) effect on number of spikes (Table-4). However, maximum of 254.1 spikes m[-2] were produced in no-cut treatment while 252 spikes were noted in cut treatment. As far as the effect of seeding rates is concerned, it was significantly affected and statistically similar number of spikes (270.4, 281.8) was recorded with the highest seed rate of 220 and 180 kg seed ha^{-1}, respectively. Minimum number of spikes (209.4) was produced with the normal seed rate of 100kg ha^{-1}. These findings are in conformity with Tompkins

et al. (1991) who found that seeding rate for wheat had a direct influence on the number of spikes and grain yield. Our results are further supported by Kilic *et al*. (2010) who reported that different seeding densities significantly affected spikes unit^{-1} area. The interaction between SR x C is presented in figure 2. It indicated that as seeding rate increased from 100 to 220 in combination with cutting treatment number of spike increased in linear manner while in case of no cut treatment number of spike reduced when seed rate was increased from 180 to 220kg ha^{-1}. Maximum spikes in increased planting density in no-cut and cut plots might be attributed to maximum partitioning of assimilates into the sink, in contrast, to cut treatment having lower seed rate which produced less number of spikes m^{-2}.
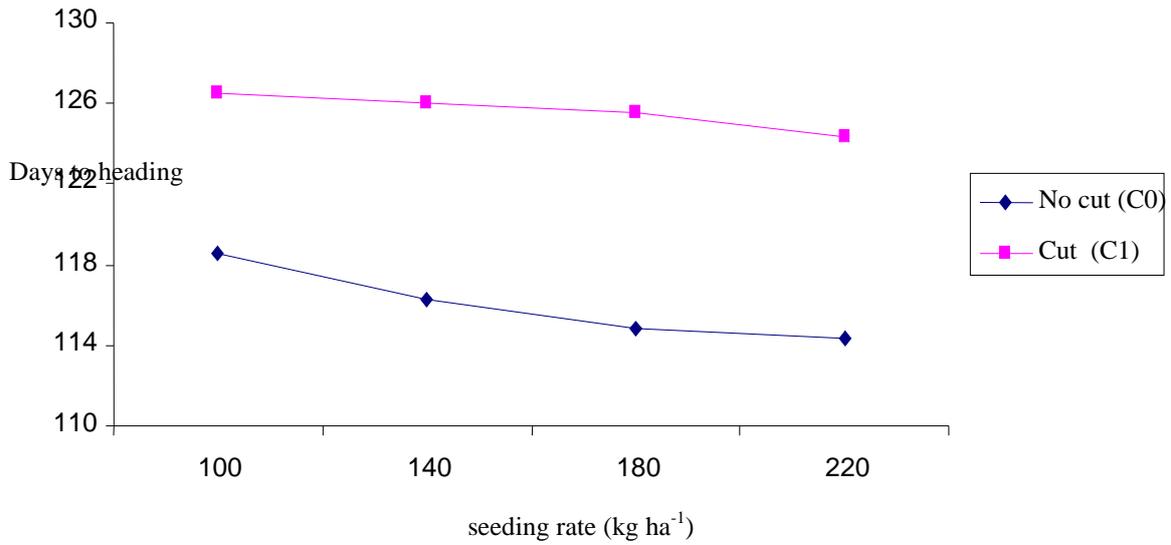

Fig.1. The interaction between seeding rates and cutting treatment for days to heading of DP wheat.
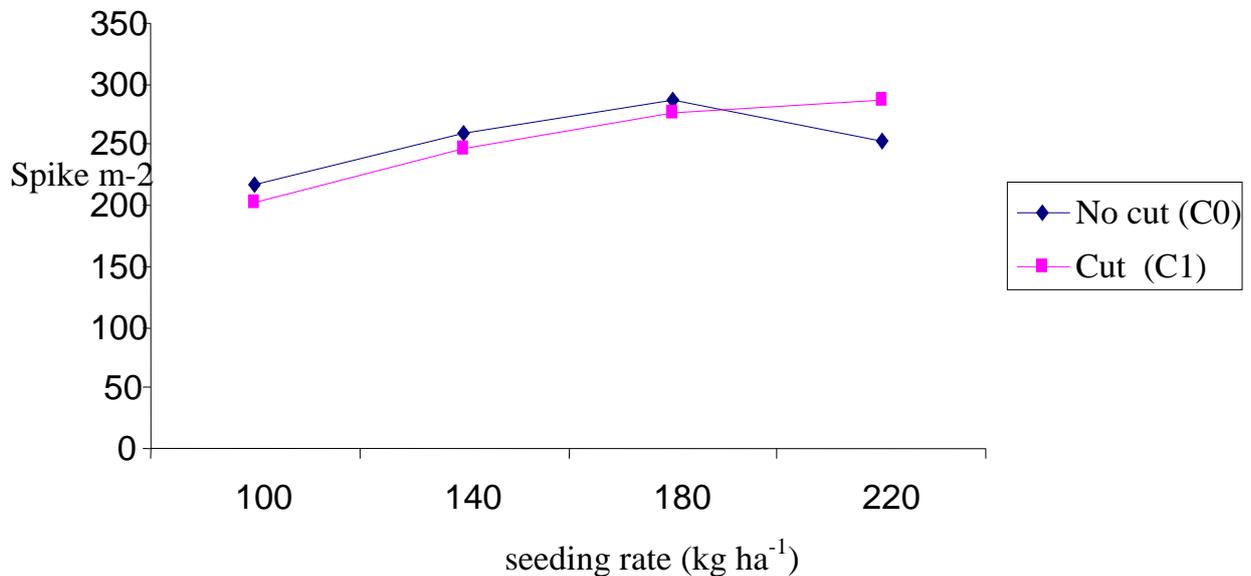
Fig. 2. The interaction between seeding rates and cutting treatment for number of spike m^{-2}.

Thousand-grain Weight (g)

Thousand grain weight was significantly (p<0.05) affected by cutting treatments wherein C0 produced grain weight of 41.65 g as compared to 38.65 g recorded in C1 treatment (Table 4). It might be due to the decapitation stress, cutting down its leaf area, which resulted in less partitioning of assimilates into the sink. These results are supported by Arif *et al*. (2006) who recorded higher seed weight (35g) in no-cut treatment as compared to cut plots (31 g). Shuja *et al*. (2010) also noted significant differences in grain weight for clipping. The data further showed that grain weight was non-significantly (p<0.05) affected by seeding rates however; the maximum grain weight (40.90g) was recorded with normal seed rate of 100 kg ha^{-1}. Hussain *et al*. (2001) found non-significant (p<0.05) difference in grain weight due to seeding densities. The interaction of cutting treatments and seeding rates revealed that maximum 1000 grain weight (42.13 g) was produced in C0 treatment with 100 kg seed ha^{-1} whereas 1000 grain weight of 41.94g was produced in the same treatment with 220 kg seed ha^{-1}. Minimum grain weight (38.0g) was obtained with 180 kg seed ha^{-1} in C1 treatment.

Biological Yield (kg ha^{-1})

Cutting treatment significantly (p<0.05) reduced the biological yield of wheat (Table 5). No-cut treatment produced maximum of 11253 kg ha^{-1} as compared to cut plots, which yielded 10252 kg ha^{-1} biological yield. It might be attributed to significantly lower leaf area, less number of tillers and grain weight attained by cut treatment thereby, undermining photosynthetic efficiency to some extent. Lopez-Bellido *et al.*(1998) reported that higher dry matter production is associated with improved photosynthetic capabilities. Similarly, seeding rate also showed significant (p<0.05) differences among treatments for biological yield. The use of highest seed rate produced maximum biological yield of 11690 kg ha^{-1}. It was, however, statistically at par with 180 kg seed ha^{-1}, which produced biological yield of 10900 kg ha^{-1}. Minimum biological yield (9925 kg ha^{-1}) was recorded with normal seed rate of 100 kg ha^{-1}. The reason of maximum biological yield obtained with the higher seed rates could be due to the production of more number of plants unit^{-1} area. Tompkins *et al*. (1991) also found that pre-anthesis biomass was higher with high seed rates. Seed rate and cutting interaction was non-significant (p<0.05), however, maximum biological yield (12375 kg ha^{-1}) was recorded in no-cut treatment with 220 kg seed ha^{-1}. Minimum biological yield of 9350 kg ha^{-1} was produced by cut treatment with normal seed rate.

Table 5. *Plant height (cm), biological yield (kg ha⁻¹) and grain yield (kg ha⁻¹) of DP wheat as affected by sowing date and seed rate.*

Seed rate (kg ha⁻¹)	Plant height (cm)	Biological yield (kg ha⁻¹)	Grain yield (kg ha⁻¹)
100	116.6	9925 c	3895.0 b
140	119.3	10500 bc	4364.0 a
180	118.8	10900 ab	4602.0 a
220	117.6	11690 a	4741.0 a
LSD$_{(0.05)}$	Ns	807	415.1
Cutting treatments			
No Cut (C0)	119	11253 a	4482
Cut (60 DAS)	117	10252 b	4318
LSD $_{(0.05)}$	Ns	570.70	Ns
Interactions	**Significance level$_{(0.05)}$**		
Seed rate (SR) x Cutting (C)	Ns	Ns	Ns

Means of the same category followed by different letters are significantly different from each other.

* = significant at 5% level of probability

Ns = non significant at 5% level of probability

Plant Height (cm)

Plant stature affects crop in several ways and have a direct and positive effect on biological yield. Height of the crop is mainly controlled by the genetic makeup of a genotype as well as environmental factors (Shahzad *et al*., 2007). Neither cutting nor seeding rates had a significant effect on plant height in the present study (Table 5). However, taller plants of 119.1 cm were recorded in no-cut treatment while cut plots produced short statured plants of 117.0 cm. Shuja *et al*. (2010) also found that plant height was non-significantly different for clipped and un-clipped cultivars. Similarly, tallest (119.3 cm) plants were produced by using seed rate of 140 kg ha⁻¹ as compared to plant height of 116.6 cm noted in plots with seed rate of 100 kg ha⁻¹. The interaction between seeding rates and cutting was non-significant (p<0.05) for plant height. No-cut treatment with 180 kg seed ha⁻¹ produced tallest plants of 120.2 cm. Short stature plants (114.5 cm) were recorded in cut plots of 100 kg seed ha⁻¹. Sulieman (2010) reported that plant height increased by increasing seeding rate while in contrast, Hussain *et al*. (2001) reported that seed rate had no significant effect on plant height.

Grain Yield (kg ha⁻¹)

Grain yield is a function of mainly three components i-e spike per unit area (SPU), kernels spike⁻¹ (KPS), and Kernel weight (KW).The data shown in Table-5 revealed that C0 and C1 treatments had no significant (p<0.05) effect on wheat grain yield. C0, however, produced more grain yield of 4482.1 kg ha⁻¹ than C1 treatment (4318.3 grain yield kg ha⁻¹). Although cut treatment had significantly low grain weight, less leaf area index and number of tillers than no-cut treatment however, its yield was propelled by non-significant differences due to statistically similar number of grains spike⁻¹ and number of spikes m⁻² between these two treatments. Although kernel weight does exert an influence on grain yield, numerous sowing rate experiments have demonstrated that its influence is generally smaller than those of SPU or KPS (Shah *et al*., 1994). Bonachela *et al*. (1995) concluded that forage production was not related to grain yield reductions due to winter clipping. Light to moderate grazing of winter wheat before first hollow stem had little or no effect on wheat grain yield, but wheat grazing past first hollow stem reduced grain yield (Fieser *et al*., 2004). Trimming of leaf area to one-half, for example, at the beginning of the rapid grain growth period did not reduce grain yield and plants compensated for the reduced leaf area by increasing stomatal conductance (Richards, 1996). The difference among seeding rates for grain yield was significant (p<0.05). Maximum grain yield of 4741 kg ha⁻¹ was recorded with 220 kg seed ha⁻¹ which was statistically at par with grain yield of 4602 and 4364 kg ha⁻¹obtained with 180 and 140 kg seed ha⁻¹, respectively. Minimum grain yield of 3895 kg ha⁻¹ was recorded with normal seed rate of 100 kg ha⁻¹. Loverlas *et al*., (2004) found that most of the varieties giving the highest yields with planting densities of 400 to 500 plants (m⁻²). Ozturk *et al*. (2006) recommended a seeding rate of 525 seeds (m⁻²) for winter sowing, and 575 seeds (m⁻²) for freezing and spring sowing. Carr *et al*. (2003) also found a positive quadratic relationship between grain yield and seeding rate. The interaction between cutting treatments and seeding rates was non-significant for grain yield. Maximum grain yield (4810.5 kg ha⁻¹) was obtained with 220 kg seed ha⁻¹ in cut treatment, followed by grain yield (4695.5 kg ha⁻¹) with 180 kg seed ha⁻¹ in no-cut treatment. Lowest grain yield (3690.2 kg ha⁻¹) was recorded with 100 kg seed ha⁻¹ in cut treatment.

CONCLUSION

Keeping in view the findings of present study it is concluded that dual purpose wheat with seed rate of 180 kg ha⁻¹ is recommended for getting fodder at the fodder scarce period from mid December to mid January with out

any reduction in grain yield and by increasing profitability than wheat crop aimed for grain weeping only purpose.

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