COMPARATIVE PRODUCTIVITY EVALUATION OF DWARF AND TALL WHEAT CULTIVARS FOR DUAL PURPOSE UNDER DIFFERENT SEED RATE AND FERTILIZER LEVELS

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SUMMARY

This research work was carried out to evaluate the performance of dual purpose wheat utilized for fodder and grain yield grown under different seed rate and fertilizer levels. Cultivation of dual purpose *i.e.* both grains and fodder together may be a good option forreducing the burden of rapidly increasing human population. Wheat may be a better option to mitigate the shortage of grains as well as fodder. Many works have been carried out considering dual purpose cereals but the production potential still has been a big limitation. Among various agronomical methods, variable rate of fertilizer application and seed rate are very crucial factor which directly affect the yield potential of crop. Nitrogen is one of major macronutrient which plays a crucial role in crop growth influencing major physiological activities including photosynthesis and protein content. Seed rate is directly related to canopy expansion and solar radiation interception, thereby strongly influencing the use of environmental resources by changing relative importance of intra and inter plant competition for light, water and nutrients during crop development and there by affects wheat yield. Looking at the importance of the issue, this review was carried out to evaluate the effect of different seed rates and fertilizer levels on the fodder and grain yield of dual purpose wheat genotypes for enhancing the productivity. Growing dual purpose wheat is gaining enhanced importance. Parameters discussed in the manuscript may be taken into consideration for increased productivity. Deep agro-physiological parameters are required for understanding the factors controlling both vegetative growth and grain development in wheat for serving both dual purposes.

Key words : Dual purpose, fodder, Fertilizer levels, seed rate, wheat cultivars

At present, India faces a net deficit of 35.6% green fodder, 10.9% dry crop residues and 44% feed (Vision, 2013). To mitigate the continued shortage of green fodder for animal consumption and grains for human, the conventional cereal crops need to be grown for dual purpose under irrigated farming system (Naveed, 2013; Dove *et al.,* 2014; Jarial, 2014 and Dhaka, 2013). Among major coarse cereals, wheat has potential to produce more grain yield along with substantially higher green fodder. It is a valuable source of high quality forage and also rich in protein, energy, nutrients but low in fibre content (Hossain, *et al.,* 2003).

Nitrogen (N) application and seed rate are important management inputs, which significantly affects yield and yield components of wheat (Bisth, *et al.,* 2004). Seed rate strongly influences the exploitation of environmental resources by changing relative importance of intra and interplant competition for light, water andnutrients during various growth stages of crop and thereby affects wheat yield considerably. Further for full exploitation of the higher yield potential of traditional, high yielding varieties as well as dual purpose varieties, increased N application is need of present time (Roberts, 2009). Many studies on the N budget have been conducted to improve the general understanding of the N cycle, environmental consequences of increased N application to croplands, and possible strategies for achieving sustainable intensification of crop production at global (Gruber *et al.,* 2008) or national scale (Yuan *et al.,* 2017; Shahzed *et al.,* 2017).

Many research works has shown the importance of including organic fertilizers or fertilizers to improve productivity and consequently the productivity of agricultural soil with excellent results (Sharma *et al,* 2018). In this context, increases in agricultural land productivity that satisfy the food demand and the animals nutritional needs is thenecessity of present time to sustain food security.

It is well known that climate, directly and indirectly, affects agricultural productivity to a great extent (Rahman and Anik, 2020). Most affected factor by climate change is agricultural productivity and it has been continuously reducing, which directly impacts the well-being of families (Soobhany, 2019; Liu *et al.,* 2020; Pravalie *et al.,* 2020). Climate change results into the loss of top fertile layer of soil. Temperature variations caused by climate change also affects the availability of water for irrigation, and the emergence of new pests.

In a country like India, where agriculture and animal husbandry are complimentary to each other and livestock rearing is integral part of rural economy, food security is directly linked with fodder availability. Dual purpose crops are an attractive management option for farmers because these crops provide food grains as well as high nutritional forage, which is conducive to livestock weight gain. It also provides an alternative source of feed during a feed gap period and the double income gained from grain and livestock feed improves the farm profit and living standards of farmers. This new approach can boost production of food for people and feed for livestock. Higher yield and benefit cost ratio of dual purpose wheat can be obtained by practicing different seed rate, cutting and fertilizer management practices within a production system. A brief resume of the research work done so far pertaining to "Evaluation of tall and dwarf wheat (*Triticum aestivum* L.) for dual purpose under different seed and fertilizer levels" has been reviewed under the following heads:

Effect of cutting management in wheat

India constitutes 13 per cent of the global wheat sown area and about 12.5 per cent of the global production. India has about 512 million total livestock population and 119 million milch animals which require huge quantity of good quality fodder for fulfilling the current demands of milk production. Increasing milk productivity in view of fodder deficiency, particularly in arid and semiarid regions, has also been a major challenge for the farmers in the country. By growing cereal crops as dual purpose crops fodder shortage in the lean seasons can also be reduced to some extent as reported by various scientists (Singhal *et al.,* 2006 and ICAR Annual Report, 2009-2010). According to Carver *et al*. (2001), more than 50% of the winter wheat acreage in the Southern Great Plains of the United States is used for the dual purpose *i.e* grazing cattle and harvesting grain. Kumar *et al.* (2014) reported that if wheat or barley is cut close to the ground before the second leaf node develops the crop will yield grain yield similar to uncut crops. The green fodder harvested is a bonus, over grain and straw produced under conventional agronomic practices. Wheat crop regenerates vigorously when cut above second node as reflected by dynamic NDVI measurements taken with Green Seeker Optical Sensors for 55-60 days old crop (Kamboj, 2011). In the USA, average fodder dry matter yield of forage wheat varieties is about 3 t/ha but on the other hand some cultivars may be much more productive which have potential to yield up to 7-11 t/ha dry matter in Montana (Cash *et al.,* 2009). Sangwan *et al*. (2018) reported that no cut treatment with 60 and 75 kg N/ha applied at sowing 1/2 + 1st irrigation 1/2 resulted in significantly lower grain yield than cut at 55 DAS at 5 and 10 cm stubble height (SH) with 75 kg N/ha applied at sowing 1/3 + after cut 2/3 and 10 cm SH with 60 kg N/ha applied at sowing 1/3 + after cut 2/3. This reduction in grain yield under uncut plot might be due to lodging of tall wheat which resulted in decreased partitioning and decreased translocation of assimilates to sink.

Jarial (2014) observed that improved variety VL 829 had significant quantity of extra green fodder (about 3.20 Mt/ha) in the lean season without any significant reduction in the grain and straw yields after harvesting crop for fodder at 79 days after sowing (DAS). However, after harvesting the crop for fodder, the grain yield in corresponding varieties was 37.41, 35.89 and 51.52 q/ha, respectively, which showed that harvesting the fodder increased grain yield by 13.7, 11.6 and 3.9 per cent over uncut condition, respectively. Singhal *et al.* (2008) reported that wheat crop, irrespective of the variety, can be harvested 60 DAS with stubble height 10 cm for fodder purposes, without affecting the grain yield of crop. Grazing is typically initiated 45 to 60 DAS and is terminated at the first hollow stem stage of growth, which has been shown to be the optimal timing for grazing termination if profitability of the overall system is the primary goal (Edwards and Horn, 2010). According to Bhilare (2009), among different cutting managements, crop harvested once at 50 per cent flowering significantly improved leaf area index. Patel *et al.* (2013) also reported that the leaf area index increased with the

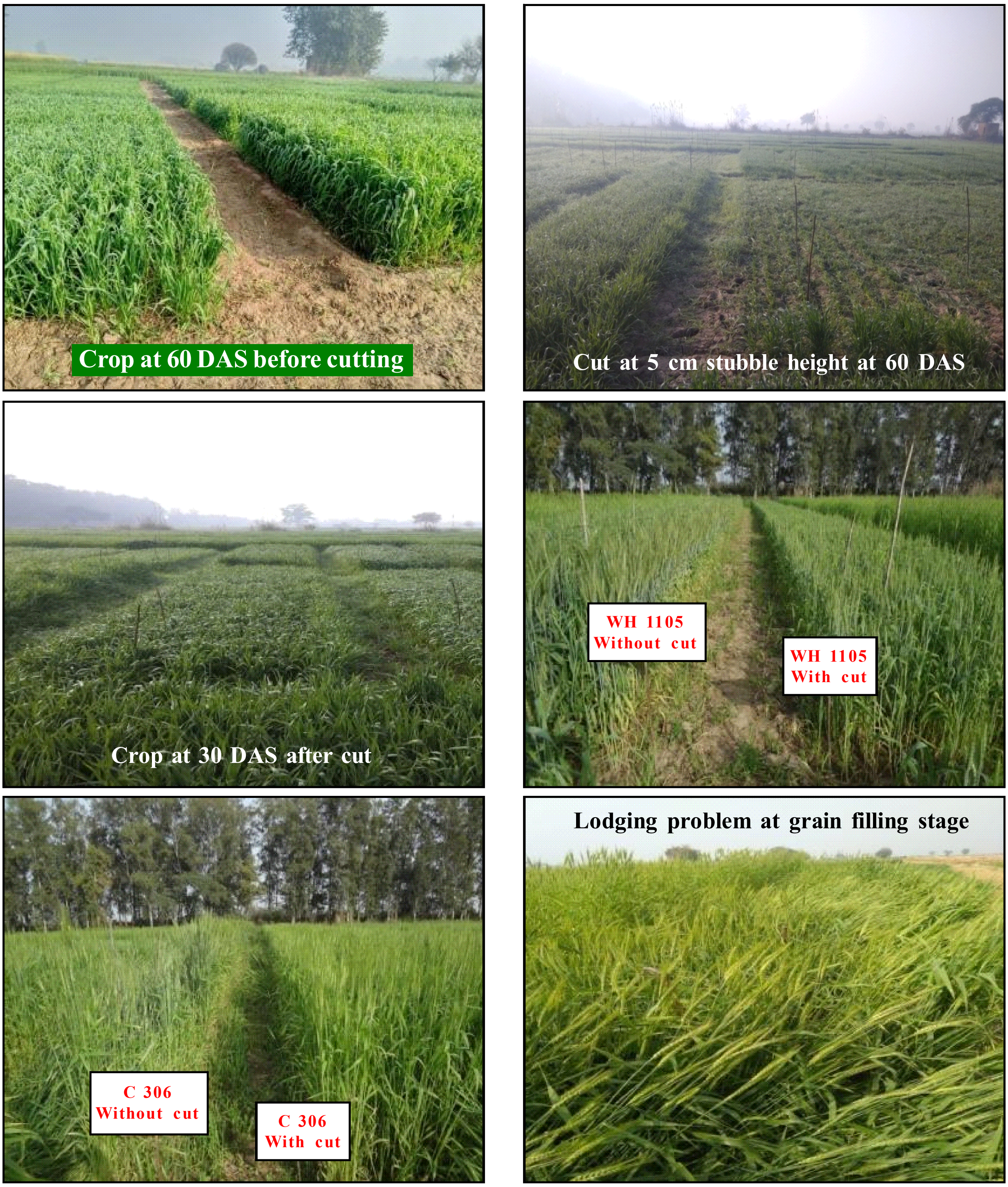

Fig. 1. Various growth stages of wheat (C 306 & WH 1105) grown for dual purpose under different seed rate and fertilizer levels.

age of the plant up to 60 DAS when the crop was harvested for the first time (first cutting). LAI is related to the biological and economic yields and increase in LAI leads to higher yield (Singh *et al.,* 2009).

Birsin (2005) observed the effects of removing flag leaf on yield parameters of wheat and found reduction in grains/spike, grain weight/spike and thousand grains weight occurred due to removal of flag leaf while increase in grain protein contents during both the years was noticed. Khaliq *et al.* (2008) also found the same results and reported that awns detachment had comparatively lesser effect on yield and yield pertaining characters as compared to flag leaf detachment, while detachment of both significantly affected individual treatment. Flag leaf area and some other components showed positive and significant correlation with grain yield which promulgated that flag leaf and awns might be used as a morphological marker, while selecting wheat varieties/lines for good photosynthetic activity and high yield.

Bisht *et al*. (2008) studied the effect of wheat varieties and their cutting schedule on fodder and grain yield and selected suitable wheat varieties for dual purpose wheat. Harvest of green fodder at 70 and 85 DAS reduced the grain yield of wheat up to 7.0 per cent; however, it was not statistically significant. It was concluded that among the various cultivars, VL *Gehun* 829 and VL 840 were the most suitable for dual purpose and can be cut after 70 and 85 DAS for green fodder as both stage of cut produced similar yield attributes, thereby ensuring fodder and food security. Tomar *et al.* (2001) assessed the potential of wheat production for green fodder cum grain in three varieties *viz.,* UP 2003, UP 2338 and WH 542 and found that harvesting green fodder at 60 or 70 DAS had good amount of green fodder, but grain yield was significantly lower as compared to uncut control. Yuan *et al.* (2002) reported a reduction in spring wheat growth due to clipping of leaves at seedling stage. Heavy clipping resulted into a serious reduction in yield, compared with light clipping- cutting half of the leaves.

On the other hand, Choudhary and Suri (2014) in their study at Agriculture University, Palampur reported significant reduction of grain yield of dual purpose wheat by 28.6 per cent from 21.00 to 15.00 q/ha and straw yield by 28.8 per cent from 30.45 to 21.39 q/ha under cut condition. Afridi *et al.* (2010) in a study at Agriculture University, Peshawar found that spikes/m^2 of wheat significantly reduced by 17.0 per cent from 382 to 316 spikes/m^2, grains/spike significantly reduced by 8.7 per cent from 46 to 42 grains/spike, test weight significantly reduced by 6.7 per cent from 38.5 to 35.9 g under cut condition. They also reported significant reduction in grain yield, biological yield and harvest index by 22.8, 15.08 and 10.3 per cent from 3,370 to 2,601 & 10,902 to 9,176 kg/ha and from 39 to 35 per cent under cut condition. Naveed *et al.* (2014) in their study at Agriculture University, Peshawar observed that the number of tillers/m^2 was significantly reduced by 9.4 per cent from 266.1 to 241.2, grains/spike significantly reduced by 3.3 per cent from 53.9 to 52.0, spike length significantly reduced by 2.4 per cent from 11.3 to 11.0 cm, number of spikes/m^2 significantly reduced by 5.9 per cent from 254.1 to 252.6 and 1000-grain weight significantly decreased by 7.2 per cent from 41.65 to 38.65 g under cut (60 DAS) condition. They also reported that plant height reduced by 1.7 per cent from 119 to 117, grain yield significantly reduced by 3.7 per cent from 4482 to 4318 kg/ha and biological yield reduced by 8.9 per cent from 11,253 to 10,252 kg/ha under cut (60 DAS) condition. Waheddullah *et al.* (2018) revealed that, grain yield significantly reduced by 9.4 per cent from 4,093 to 3,710 kg/ha and straw yield by 19.7 per cent from 7,895 to 6,338 kg/ha under cut (55 DAS) condition.

Iqbal *et al.* (2016) found that fodder production was increased from 130 to 3500 kg/ha with delaying cutting from Zadok growth stage ZGS-12 to ZGS-18, whereas grain yield was decreased from 4400 to 2750 kg/ha with delayed cutting. No cut produced taller plants (88 cm) as compared to cut at ZGS-18 (76 cm). Similar inclination was observed in number of productive tillers/m^2, grains/spike and 1000-grains weight which perform better in the no cut plots. Similarly, days to heading (122), anthesis (125) and maturity (162) were also delayed with cut. Afridi *et al.* (2010) reported that fertilizer nitrogen supplementation produced more spike/m^2 (349), grains/spike (44), thousand grains weight (37.21 g), grain yield (2,985 kg/ha), biological yield (10,039 kg/ha) and harvest index (37%) as compared to control. Whereas, the decapitation stress decreased spikes/m^2 (316), grains/spike (42), thousand grains weight (35.92 g), grain yield (2601 kg/ha), biological yield (9176 kg/ha) and harvest index by (35%) as compare to no cut plots.

Effect of seed rates on dual purpose wheat

Demari *et al.* (2018) in their study, conducted in Brazil, reported that increase in plant density from 225 to 300 plants/m^2 in wheat significantly increased the LAI at grain filling stage by 92.7 per cent from 240.2 to 462.9 cm^2 under one cut which was rapidly regenerated in comparison to without cut where increase in LAI at same stage was reported to 57.7 per cent from 541.7 to 854.3 cm^2.

Choudhary and Suri (2014), conducted a research at Agriculture University, Palampur and found that grain yield of dual purpose significantly improved by 33.3 per cent from 15.00 to 20.00 q/ha and straw yield increased by 33.7 percent from 21.39 to 28.59 q/ha with increase in seed rate from 100 to 125 kg/ha. Naveed *et al.* (2014) also reported that the fresh forage yield was significantly increased by 26.2 per cent from

2,886 to 3,642 kg/ha, number of tillers/m^2 significantly increased by 15.1 per cent from 231.9 to 267.0, grains/spike significantly reduced by 3.7 per cent from 53.8 to 51.0, spike length significantly reduced by 4.5 per cent from 11.2 to 10.7 cm, number of spikes/m^2 significantly increased by 11.8 per cent from 252.1 to 281.8 and thousand grain weight significantly increased by 1.0 per cent from 39.7 to 39.8 g with increase in seed rate from 140 to 180 kg/ha. Reduction in plant height by 4.2 per cent from 119.3 to 118.8, increased in biological yield by 3.8 percent from 10,500 to 10,900 kg/ha and grain yield was significantly increased by 5.5 per cent from 4,364 to 4,602 kg/ha with increase in seed rate from 140 to 180 kg/ha was also observed by Naveed *et al.* (2014). Significant interaction of seeding rate and cutting was documented for number of days to heading and number of spikes/m^2. It is accomplished that dual-purpose wheat system, with 140 kg/ha seed rate, had higher ability of providing fodder in cold winter, though it produced less grain yield as compared to no cut plots.

Iqbal *et al.* (2012) in their study conducted in Punjab reported that plant height of wheat significantly increased by 3.6 per cent from 94.99 to 98.33 cm, effective tillers/m^2 increased by 12.9 per cent from 404.40 to 464.60, spike length increased by 6.1 per cent from 12.07 to 12.81 cm, grains/spike increased by 6.5 per cent from 42.13 to 45.27 and thousand grain weight increased by 6.5 per cent from 44.39 to 47.28 g with increase in seed rate from 125 to 150 kg/ha. They also observed increase in biological yield by 3.4 per cent from 8975 to 9261 kg/ha, grain yield by 7.4 per cent from 3949 to 4242 kg/ha and harvest index by 3.0 per cent from 43.80 to 45.48 per cent with increase in seed rate from 125 to 150 kg/ha.

Laghari *et al.* (2011) evaluated the effect of different seed rates (125, 150, 175 and 200 kg/ha) on growth, yield and nutrient uptake of wheat varieties (TD-1, TJ-83 and Mehran-89) and reported that plant traits were significantly affected by different level of seed rates. Crop sown at lower seed rate had better growth, yield, nutrient uptake and low lodging tendency. Maximum tillers, spike length, grains/spike, grain weight/spike, seed index, biological yield, grain yield, harvest index, dry matter, crop growth rate and low lodging were found in TD-1 sown at 125 kg/ha seed rate. However, higher seed rates (200 kg/ha) resulted in delayed maturity, greater internode length and higher lodging in Mehran-89. However, TJ-83 was in efficient and recorded minimum values of all the growth, yield, nutrient uptake and other traits. It was concluded that wheat variety TD-1 could be sown at optimum seed rate of 125-150 kg/ha for better growth, yield, nutrient uptake and minimum lodging tendency. Yadav and Dhanai (2017) studied the effect of different seed rate (100, 125, 150 kg/ha) and nitrogen levels (100, 120, 140 kg/ha) on a semi dwarf 'K-8020', variety of wheat and found that the treatment of nitrogen level at 140 kg N/ha, made in conjunction with 150 kg seed rate/ha, are best than all other treatments for achieving the highest traits of expression of number of shoot length, plant height, seed yield (q/ ha), straw yield (q/ha), biological yield (q/ha) and quality parameters. Whereas, treatment of nitrogen level at 140 kg N/ha made with 100 kg seed rate/ha are best than all other treatments for achieving the highest traits of expression of dry matter (g), spike length (cm), number of spikes/ear, number of seed per spike, 1000 seed weight but combination of 100 kg N/ha with 125 kg seed rate/ha achieving the highest traits of expression of harvest index, thus promising to boost the productivity of wheat.

Kabir *et al.* (2009) also evaluated the effect of different seed rates (100, 120, 140 and 160 kg/ha) on the performance of wheat cv. Gourab and observed that the highest plant height (82.36 cm), total tillers/ plant (8.99), effective tillers/plant (3.49), spike length (8.05 cm), spikelets/spike (15.50), filled grain/spike (31.05), grain yield (2.82 t/ha), straw yield (3.73 t/ ha), biological yield (6.55 t/ha) and harvest index (42.43%) were recorded from the seed rate of 140 kg/ha.

Effect of fertilizer levels on dual purpose wheat

Afridi *et al.* (2010) in their study at Agriculture University, Peshawar found that spikes/m^2 of wheat significantly increased by 4.5 per cent from 352 to 368 spikes/m^2 increased in grains per spike by 7.0 per cent from 43 to 46 grains/spike and reduction in test weight by 4.8 per cent from 37.89 to 36.08 g was observed in increase in nitrogen level from 150 to 200 kg/ha.They also reported that increase in grain yield by 6.5 per cent from 3,018 to 3,213 kg/ha increase in biological yield by 4.4 percent from 10,464 to 10,923 kg/ha and harvest index was not affected by nitrogen dose increased by 150 to 200 kg/ha but decrease in harvest index was observed from 100 to 150 kg/ha in same study. Khalil *et al.* (2011) in their study found that the fodder dry matter production was significantly increased by 9.6 per cent from 267.13 to 292.81 kg/ ha, increased plant height by 7.4 per cent from 76.21 to 81.88 cm plant height and increased in productive tillers/m^2 by 2.08 per cent from 332.92 to 339.83 cm with nitrogen dose from 80 to 160 kg/ha. Number of grains per spike significantly increased by 6.72 per cent from 42.29 to 45.13 grains/spike and increased in test weight by 3.34 per cent from 30.88 to 31.91 g. Biological yield was significantly increased by 1.43 per cent from 9,953 to 10,095 kg/ha and reduction in grain yield by 2.46 per cent from 2,891 to 2,962 kg/ha was observed in increase in nitrogen dose from 80 to 160 kg/ha.

Shahid *et al*. (2015) found maximum agronomic nitrogen use efficiency (27.39 kg/kg), physiological nitrogen use efficiency (41.03 kg/kg) and 1000-grain weight (37.50 g) were observed in treatment where nitrogen was applied at the rate of 75 kg/ha. Iqbal *et al.* (2012) in their study conducted in Punjab, reported an significant increase in plant height by 3.5 per cent from 98.72 to 102.18 cm, increased effective tillers/m^2 by 3.1 per cent from 461.6 to 472.8, increased spike length by 10.5 per cent from 13.00 to 14.36 cm, increased grains/spike by 4.0 per cent from 45.89 to 47.67 and increased thousand grain weight by 6.7 per cent from 47.6 to 50.8 g with increase in nitrogen dose from 100 to 125 kg/ha. They also reported an increase in biological yield by 1.9 per cent from 9,512 to 9,695 kg/ha, increased in grain yield by 3.4 per cent from 4,477 to 4,629 kg/ha and increased harvest index by 1.4 per cent from 47.1 to 47.7 per cent was observed in increase in nitrogen dose from 100 to 125 kg/ha. Likewise, to achieve higher crop productivity and economic returns of tall wheat *i.e.* C 306 under dual purpose system in North-West India, the cutting of wheat crop for fodder at 55 days after sowing (DAS) with 10 cm stubble height and application of 75 kg N/ha at sowing 1/3 + after cut 2/3 should be adopted to obtain valuable additional fodder during winter months without yield penalty (Sangwan *et al*., 2018).

Choudhary and Suri (2014) observed that in North West Himalayas, application of NPK at 80:40:40 kg/ha + 20 kg N/ha (25% greater N) after fodder cut at 85 DAS + seed rate at 125 kg/ha (25% greater seed rate), was found as an appropriate agro-technology for harnessing the ability of dual-purpose wheat VL-829 to harvest additional green forage yield of 58.75 and 92 q/ha under rainfed and irrigated conditions, respectively, with respective slight grain yield reduction by 4.76 and 8.89% over check (no forage cut + 80:40:40 kg NPK/ha + seed rate @ 100 kg/ha). Naveed *et al.* (2013) reported that maximum number of productive tillers/m^2, number of grains/spike, leaf area index and duration 112 DAS, crop growth rate and grain yield was recorded in plots receiving 75 per cent recommended dose of nitrogen after cut. Fresh and dry forage yield were maximum either when full dose or 75 per cent dose of the recommended nitrogen was applied at sowing, but maximum benefit: cost ratio was observed in treatment receiving 25 per cent of the recommended nitrogen before cut and 75 per cent after cut.

Islam *et al.* (2017) elucidated that leaf area/tiller, days to heading, days to physiological maturity, plant height, spikes/m^2, spike length, grains/spike, thousands grains weight, biological yield and grain yield were significantly affected by various levels of phosphorus. Maximum weight of thousand grains (41.8 g) was recorded in plots where 75 kg P_2O_5/ha was applied. Contrary to it, plots that received phosphorus at the rate of 90 kg/ha produced maximum leaf area/tiller (128.3 cm^2), days to heading (129), days to physiological maturity (166), plant height (92.6 cm), number of spikes/m^2 (363), spike length (11.8 cm), number of grains/spike (45), biological yield (13,056 kg/ha) and grain yield (3,991 kg/ha). It was accomplished that phosphorus application at 90 kg/ha showed best performance.

Enhanced dose of nitrogen led to an increased number of productive tillers (Hussain *et al.,* 2006 and Ali *et al*., 2010). The effect of seed deterioration, plant density and nitrogen fertilizer application on yield, yield components and some qualitative traits of wheat was studied by Mosanaei (2017). He took nitrogen consumption at 3 levels (recommended rate, 15 and 30 per cent higher than the recommended rate, *i.e.,* 125, 143.75, and 162.5 kg N/ha, respectively) and concluded that application of recommended rate of nitrogen fertilizer in the first and the second year resulted in the highest average of number of seeds per spike and spike length while the highest grain yield was achieved in the recommended and 30 per cent higher than the recommended application rate of nitrogen fertilizer (4,062 and 4,166kg/ha, respectively) in the second year.The effect of application of increasing levels of nitrogen *i.e*., RDN+25% (150 kg N/ha) and RDN+50% (180 kg N/ha) led to an increased content of amino acids and proteins whereas RDN-25% (90 kg N/ha) and RDN, (120 kg N/ha) doses resulted in decreased content in wheat seeds was studied by Asthir *et al*. (2012).

Neelam *et al*. (2018) in their study conducted at CCS Haryana Agricultural university, Hisar reported the highest grain yield (46.8 q/ha) of barley was obtained with application of 120 kg nitrogen/ha, which was significantly higher over 60 kg nitrogen/ha (42.3 q/ha). The highest number of productive tillers/m^2 (446) was reported with application of 120 kg nitrogen/

ha, which was significantly higher over 60 kg nitrogen/ha (422) but statistically at par with 90 kg nitrogen/ha (443). Among different nitrogen levels, highest straw yield (74.7 q/ha) was recorded in treatment treated with 120 kg nitrogen/ha which was closely followed by 90 kg nitrogen/ha. Among various genotypes evaluated in study, PL-874 produced significantly highest grain yield (48.8 q/ha) over other genotypes except BH-976 (47.3 q/ha). The highest number of productive tillers/m^2 (476) was reported in DWRB-92 genotype, whereas maximum grains/spike was obtained in BH-902 genotypes, which was significantly higher over other genotypes, In same study, highest harvest index (39.3%) was recorded in RD-2849 closely followed by DWRB-101.

Effect on quality in dual purpose wheat

Nitrogen is essential for protein production in plants, which is the direct or indirect source of protein for animal and human nutrition. Gill *et al.* (1970) reported that higher nitrogen dose and split application caused more nitrogen content (%) and uptake by wheat. The positive effects may be attributed mainly to the nitrogen rate effect since the fertilizer nitrogen use efficiency can be enhanced by split nitrogen application under appropriate environmental conditions, which resulted in higher plant nitrogen uptake (Hamid, 1972 and Ercoli *et al.,* 2013). Fisher *et al.* (1993) observed that split application of nitrogen was effective in increasing wheat grain yield and grain protein was also improved by the late application of nitrogen. Dual purpose wheat provides high quality forage for livestocks during the winter season, when other fodder sources are low in quantity and quality (Krenzer, 2000). Horn (1984) also found that dual purpose wheat can provide high quality fodder for livestock.

Atis and Akar (2018) conducted an experiment to study the effect of cutting on quality parameters of wheat at Turkey and found that increase in cutting height of dual purpose wheat from 5 to 7.5 cm increased the protein content by 1.8 per cent from 24.4 to 24.9 per cent and at 10 cm cutting height there was further increase in protein content by 6.4 per cent from 24.9 to 26.5 per cent that notify the effect of decapitation on protein quality of dual purpose wheat. Waheddullah *et al.* (2018) in their study at Agriculture University Hisar found that nitrogen content in grain by 5.6 per cent from 1.8 to 1.7 per cent, in straw by 33.3 per cent from 0.3 to 0.2 per cent and protein content by 8.0 per cent from 11.3 to 10.4 per cent under cut (55 DAS) condition. Tomar *et al.* (2001) observed that crude protein production from straw and grain was highest when the crop was harvested at maturity. Percent cost of crude protein harvested (rupees per unit) was significantly decreased to 18 and 44 per cent by harvesting at 60 and 70 days intervals, respectively.

Henz *et al.* (2016) revealed that the forage yield, the percentage crude protein and acid detergent insoluble protein had a linear relationship because of the addition of nitrogen doses. The crude protein percentage changed the estimate of all soluble carbohydrates (P=.0001) and non-fibrous carbohydrates (P=.0186), but did not influence the, nitrogen detergent fiber corrected with ash and proteins percentage contributing for content cell. The crops production (P=.0001) and the number of kernels per ear (P=.0001) showed significant difference because of the nitrogen additions dose, increasing the number of fertile flowers. The nitrogen topdressing alters forage production, the chemical composition and the production of dual purpose wheat grains subjected to grazing. Shahid *et al.* (2015) conducted an experiment to improve wheat (*Triticum aestivum* L.) yield and quality by integration of urea with poultry manure and recorded that grain crude protein contents increased with each increasing rate of applied nitrogen.

Nakano *et al.* (2008) found that application of 4.0 g N/m^2 at active tillering, grain protein content increased linearly at a rate of about 0.5% per 1.0 g N/m^2 (from 10.9% to 14.0%) with increasing N application rate (from 0 to 6.0 g N/m^2) at anthesis. However, the rate of increase in grain protein content with increasing N application rate at anthesis was greater with 0 g N/m^2 at active tillering than that with 4.0 g N/m^2 at active tillering, whereas that with 8.0 g N m^2 at active tillering was smaller than that with 4.0 g N/m^2 at active tillering. Thus, N application at anthesis is more effective than N application at active tillering for increasing grain protein content. Protein content was also increased quadratically with N rate. The average protein contents were 10.54%, 11.89%, 13.29%, 13.98%, and 14.37%, respectively, at N rates of 0, 90, 180, 240, and 300 kg/ha, respectively. Zhang *et al.* (2017) observed that grain protein and the total, essential and non-essential amino acid content significantly increased with increasing nitrogen application. It was revealed that nitrogen rate of 240 kg N/ha significantly increased protein, total amino acid, essential amino acid and non-essential amino acid content in wheat grain compared with 180 kg N/ha, but no further increases were found for these traits on treatment with 300 kg N/ha, indicating that a N rate of 240 kg/ha was already sufficient to satisfy N uptake requirements from soil, and maintain protein accumulation in wheat grain.

Economics of dual purpose wheat

Choudhary and Suri (2014) reported that the cost of cultivation was significantly increased by 3.2 per cent from 11,670 to 12,043 Rs/ha, increased in gross returns by 33.4 per cent from 22,528 to 30,062 Rs/ha, increased net returns by 65.9 per cent from 10,858 to 18,019 and benefit cost ratio was significantly increased by 61.3 per cent from 0.93 to 1.50 with increase in seed rate from 100 to 125 kg/ha.They also reported that the cost of cultivation significantly increased by 14.4 per cent from 10,200 to 11,670 Rs/ha, reduction in gross returns by 5.9 per cent from 23,940 to 22,528 Rs/ha, reduced net returns by 20.9 per cent from13,740 to 10,858 and benefit cost ratio was significantly reduced by 31.1 per cent from 1.35 to 0.93 in undercut condition.

Waheddullah *et al.* (2018) found that the cost of cultivation increased significantly by 6.6 per cent from 69,888 to 74,499 Rs/ha, gross returns by 4.6 per cent from 13,7840 to 14,4170 Rs/ha, net returns by 3.0 per cent from 67,952 to 69,671 Rs/ha and benefit cost ratio significantly reduced by 3.0 per cent from 1.97 to 1.91 under cut condition.

Lal and Saini (2017) found variation among growth parameters *i.e.* emergence, plant height, leaf area index, tillers and dry matter accumulation in bidirectional and uncut treatments. Lodging score was significantly improved from 57.3 to 0 per cent by cutting practices as compared to uncut treatments. The yield attributes and biological yield were significantly higher in uncut treatments and bidirectional planting geometry. The grain protein was recorded higher (10.55%) in uncut treatment. The economic efficiency with net returns was significantly higher in bidirectional planting techniques (Rs. 53,777/ha and Rs. 324.84/day/ha) whereas in cut at 50 DAS, net returns (Rs 55,756/ha) was found significantly higher over uncut and cut at 60 DAS.

As the population of India is increasing to an alarming rate and it results into the continuous shrinkage of agricultural land due to construction of building and other entities. Despite this, pressure on agriculture land is also increasing for production of food crops to feed such an increasing population. However, in Country like India, animal rearing for dairy products is integral part of its economy. For healthy livestock, green fodder is one of the important ingredients of animal diets. To meet out the food demand of human population as well as livestock population, it is the need of present hour to increase the area under dual purpose cereals (for green fodder as well as for grain) and to carry out more research works so that efficiency of this system can be increased to a great extent.

CONCLUSION

Growing dual purpose wheat is gaining a great importance among farmers as it increases the profitability of farmers to a great extent. Various parameters discussed in the manuscript are key points which show increase in the productivity of wheat crop. Deep agro-physiological insights are pre-requisites for understanding the various factors which controls the vegetative growth as well as development in wheat for serving both dual purposes.

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