Effect of fertilizers and cutting schedule on growth and quality of dual purpose barley crop

(Hordeum vulgare L.)

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Abstract

A field experiment was carried out at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) during Rabi season 2016-17. The experiment was laid out in Split Plot Design with three replications. Main plot were treated with fertilizer levels, F1 (60 kg N + 30 kg P2O5 ha⁻¹), F2 (80 kg N + 40 kg P2O5 ha⁻¹), F3 (100 kg N + 50 kg P2O5 ha⁻¹) and F4 (120 kg N + 60 kg P2O5 ha⁻¹) and sub plot were treated with cutting schedule as 45 DAS, 55 DAS, 65 DAS and 75 DAS. The results revealed that the growth parameters like, plant height, dry weight of plant, leaf area index (LAI) and no. of tillers at first cutting and at harvest were recorded maximum with the application of 120 kg N + 60 kg P2O5 ha⁻¹ followed by 100 kg N + 50 kg P2O5 ha⁻¹ and 80 kg N + 40 kg P2O5 ha⁻¹ respectively and significantly higher over the application of 60 kg N + 30 kg P2O5 ha⁻¹. The maximum plant height (77.28 cm) was recorded when barley crop cut as 75 DAS which was higher tune to the 12.6%, 17.57% and 32.51% over 65, 55 and 45 days after sowing. The dry matter accumulation, leaf area index and no. of tillers were also maximum in the same cutting. However, the quality parameters viz., crude protein (12.88%), crude fiber (31.87%), TDN (65.93%), WSC (10.40%), ADF (31.34%), NDF (52.49%) and Ash (13.34%) were recorded maximum with the application of 120 kg N + 60 kg P2O5 ha⁻¹ while in case of cutting schedule the maximum crude fiber (31.49%), WSC (10.80%), ADF (33.58%), NDF (54.02%) and Ash (15.20%) were found at first cut (75 DAS) where as crude protein (13.13%) and TDN (65%) obtained at first cut (45 DAS).

Keywords: growth, LAI, fresh weight, plant height, P:O: Barley and cutting schedule

Introduction

India is the largest milk producing country in the world with livestock population of 529 million and milk production 133 mt. It contributes nearly 7% in the global cereal production. Barley grain largest use as animal feed in all over the world and in India also, a major share of barley grain is used as animal feed either alone or mixture with fodder crops. Barley has tremendous potential and variation for production of very high proportion of digestible dry matter as well as protein yield per hectare. It is grown successfully in a wider range of climatic conditions than any other cereals. Barley has such morpho-physiological traits that make it suitable for dual purpose cultivation for fodder and grain production than other cereals. It is highly efficient in the utilization of water and nutrients in limiting conditions. It is high capacity of crop for tillering and regenerate after cutting and additional capacity for large accumulation of biomass. It sets seed rapidly after re-growth, thus escaping terminal stress due to high temperature and warm winds often experienced in the region. Thus, as a dual purpose (green forage and feed/grain) crop it provides a welcome boost to the confidence of forage growers and fits well for crop diversification in the integrated crop-livestock farming system. Area under barley in world is 47.5 mha with 123.7 mt production and 2.68 t/ha Productivity. Russian federation holds first position in all over the world and in India also, a major share of barley grain is used as animal feed either alone or mixture with fodder crops. Barley has tremendous potential and variation for production of very high proportion of digestible dry matter as well as protein yield per hectare. It is grown successfully in a wider range of climatic conditions than any other cereals. Barley has such morpho-physiological traits that make it suitable for dual purpose cultivation for fodder and grain production than other cereals. It is highly efficient in the utilization of water and nutrients in limiting conditions. It is high capacity of crop for tillering and regenerate after cutting and additional capacity for large accumulation of biomass. It sets seed rapidly after re-growth, thus escaping terminal stress due to high temperature and warm winds often experienced in the region. Thus, as a dual purpose (green forage and feed/grain) crop it provides a welcome boost to the confidence of forage growers and fits well for crop diversification in the integrated crop-livestock farming system. Area under barley in world is 47.5 mha with 123.7 mt production and 2.68 t/ha Productivity. Russian federation holds first position in all over the world in terms of area and production with 4.94 mha and 8.35 mt respectively.

In India, barley crop was grown over an area of 695.0 thousand hectare with a production of 1743.2 thousand tones and productivity of 2.51 t ha⁻¹ during 2012-13 (Anonymous, 2013) [1]. Uttar Pradesh is one of the most important barley growing states of India. In Uttar Pradesh, the area under cultivation of barley is about 168.0 thousand ha⁻¹ with a production of 441.0 thousand tonnes and productivity of 2.63 t ha⁻¹ (Anonymous, 2013) [1]. Dual purpose barley is an excellent alternate crop for fodder purpose. The nutritive value of green fodder is highest at 50% flowering stage and decreases after flowering stage in most of the crops. In dual purpose barley crop, stage of harvesting also determine the regenerative potential of the crop, the regeneration capacity is adversely affected by the higher stage of harvesting for green fodder.
That’s why it’s important to determine the right stage of harvesting the crop to obtain the highest green fodder as well as grain yield. In addition, suitable seed rate and cutting schedule is also important for dual purpose barley varieties for realizing higher green fodder as well as grain yield (Thomson et al., 2009)\(^{[13]}\). If it is harvested as green fodder at vegetative stage, the opportunity for producing grain is eliminated by the plants because of less subsequent new leaf area and its ability to prevent tiller senescence during the period between jointing and anthesis (Dunphy et al., 1984 and Singh et al., 2009)\(^{[2,10]}\). Several authors have agreed upon the importance of rapid regeneration of leaf area after forage removal to establish sufficient photosynthetic capacity to support maximum grain yield (Singh et al., 2009)\(^{[10]}\).

**Materials and methods**

The field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.), during rabi season 2016-2017. The experimental site falls under sub-tropical zone in Indo-gangatic plains, lies between 26.47\(^{0}\) Northern latitude, 82.12\(^{0}\) Eastern longitudes, at an altitude of about 113.0 meters from mean sea level and is subjected to extremes of weather conditions. The condition comes under sub-tropical climate with an average annual rainfall of around 1200 mm, which is mostly received from July to September with a few showers in winter. The total rainfall during course of experimentation was 42.67 mm.

Metrological conditions such as maximum and minimum temperature, distribution of rainfall, relative humidity and sunshine hours recorded during the crop period season, the lowest temperature 4.9\(^{0}\)C was recorded in the month of January and the maximum 39\(^{0}\)C in the month of April. The highest mean relative humidity 88.20\% was recorded in the month of January. Land was prepared thoroughly to obtained proper fine soil till, preserving irrigation was given to the field about 12 days prior to the sowing of the experimental crop. First ploughing was done by tractor drawn soil turning plough in order to get field free from clods, weeds and crop stubbles and two ploughing were given deeply by tractor drawn cultivator followed by planking. The field was free from clods, weeds and properly leveled for effective distribution of irrigation water. The crop variety NB 2 has sown at proper moisture, sowing was done by tractor drawn cultivator followed by planking. The field was free from clods, weeds and properly leveled for effective distribution of irrigation water.

The leaf area was measured at 45, 55, 65, 75 DAS at first cut and at harvest stage to calculate the leaf area index. The plants of 25 cm\(^2\) area were taken and green leaves were separated to record their surface area by automatic leaf area meter. All the leaves were grouped into three viz. small, medium and large. Five leaves from each plant were taken and their surface area was measured.

Area of leaves was multiplied with respective leaf number of a group and sum of all three gave the total leaf area. For obtaining leaf area index, Leaf area was divided by ground area was given by Watson 1997.

\[
\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}
\]

**Formula for calculation**

\[
\text{CP} \% = \frac{\text{Vol. of 0.01 N H2SO4 x Volume made (ml)x 0.0014 x 6.25}}{\text{Aliquot taken x Weight of sample on DW basis}} \times 100
\]

\[
\text{Crude fiber} \% = \frac{\text{Weight of (crude+ dry matter)xWeightof crude ash}}{\text{Amount of substance taken}} \times 100
\]

**TDN (Total digestible nutrient)**

The total digestible nutrient (%) was calculated by following method which was given by Moore et al. (1953)

\[
\text{TDN} \% = \text{Digestible crude protein} \% + \text{Digestible crude fibre} \% + \text{Digestible Nitrogen free extract} \% + \text{[Digestible ether extract]} \% \times 2.25
\]

**Water soluble carbohydrates**

Water soluble carbohydrate was determined by AOAC (2005).

**Acid detergent fiber**

\[
\text{ADF} \% = \frac{\text{Wt.of crucible+residue - Wt.of empty crucible}}{\text{Wt. of sampeletaken (g)}} \times 100
\]

(Formula was given by Van Soest et al. 1991)

**Neutral detergent fiber**

\[
\text{NDF} \% = \frac{\text{Wt.of crucible+residue - Wt.of neutral detergentresidual ash}}{\text{Wt. of sampeletaken(g)}} \times 100
\]

(Formula was given by Van Soest et al. 1991)

**Total ash (%)**

\[
\text{Total Ash} \% = \frac{\text{Weight of ash}}{\text{Weight of sample on DW basis}} \times 100
\]

**Results and discussion**

The data on plant growth viz., plant height, number of tillers, dry matter accumulation and leaf area index were illustrated in Table 1. The nitrogen and phosphorus levels had the significantly effect on the plant height. Maximum plant height was recorded under treatment F\(_5\) (120 kg N + 60 kg P\(_2\)O\(_5\)ha\(^{-1}\)) at both the stages 1\(^{st}\) cut and at harvest, which was mainly due to more availability of nitrogen and phosphorus. Higher nitrogen and phosphorus levels resulted in higher nitrogen and phosphorus uptake, which could ultimately result into increased protein synthesis, cell division and cell elongation and finally expressed morphologically on increased in height of the plant. Similar findings were reported by Singh et al. (2003)\(^{[10]}\).
Plant height was affected significantly due to cutting schedule the maximum plant height was recorded under the treatment C1 (75 DAS) at first cutting and at final harvest stage the maximum plant height (79.79 cm) was recorded under the treatment C1 (45 DAS) due to more time duration availability for the regenerated crop for the growth and development. Similar findings were reported by Sood et al. (1992) [12].

Initially the number of tillers m⁻²in all the treatments was slow but it increased steadily till first cutting. Different fertilizer levels had significant effect on the number of tillers m⁻²at all the successive stages of the plant growth. Maximum number of tillers m⁻²was recorded under treatment F1 (120 kg N +60 kg ha⁻¹) at both the cut. Similar findings were reported by Kumawat and Jat (2006) [8].

Number of tillers m⁻²of barley was affected significantly due to cutting schedule at all the stages of crop growth. It increased successively till the first cutting. The rate of increase number of tillers m⁻²was slow during initial stage due to slow crop growth but it increased rapidly at later stages after first cutting. Significantly higher number of tillers m⁻²was recorded under the treatment C1 (75 DAS) at first cut, at the harvest stage the maximum number of tillers m⁻²was recorded under the treatment C1 (45 DAS). This was due to more assimilation and utilization of available nitrogen and phosphorus by the growing plants during the entire grand growth period due to more time duration availability for regenerated crop, as the result of this number of tillers m⁻²which favored to increase. The lowest number of tillers m⁻²were recorded under the treatment C1 (45 DAS) at first cutting and C4 (75 DAS) at final harvest stage. Similar findings were reported by Manohar et al. (2017) [6].

Fertilizer levels had significant effect on the dry matter accumulation at all the successive stages of the plant growth. Maximum dry matter accumulation was recorded under treatment F1 (120 kg N +60 kg P₂O₅ha⁻¹) at the first cut and at harvest stages. This might be due to higher collective contribution of various growth characters likes, plant height, number of shoot, leaf area index and yield of vegetative part. Similar findings were reported by Singh et al. (2003) [11].

Dry matter accumulation of barley was affected significantly due to cutting schedule at all the stages of crop growth. It increased successively till the harvest. The rate of increase in dry matter production was slow during initial stage due to slow crop growth but it increased rapidly at later stages up to first cut and till the harvest due to bright sunshine and rise in temperature. Significantly higher dry matter accumulation was recorded under the treatment C4 (75 DAS) at first cut and at harvest stage the maximum dry matter accumulation was recorded under the treatment C1 (45 DAS). This might be due to more assimilation and utilization of available nitrogen by the growing plants during the entire grand growth period due to more time duration availability for regenerated crop, as the result of this more dry matter accumulation in root, stem, leaves and grains which favoured to increase the dry weight. The lowest dry matter was recorded under the treatment C1 (45 DAS) at first cut and C4 (75 DAS) at harvest stage. This could be mainly due to the fact that growing plants did not achieve sufficient nitrogen and phosphorus leading to poorer growth of the crop which consequently resulted into lowest dry weight, Kaur et al. (2013) [4].

Initially leaf area index (LAI) increased very slowly when crop cut at early stage after that furthered in a rapid expansion up to harvesting, later declining trend in LAI was observed. Slow increased in LAI at initial stage was due to less time available for growth and development of the plant. Rapid increased up to 75DAS was possibly because of increased rate of light absorption, high photosynthetic activities and increased absorption of nutrient from the soil. The reduction in LAI at harvest was caused possibly due to increased senescence. The leaf area index increased with increasing the nitrogen and phosphorus levels and was recorded maximum under treatment F4 (120 kg N 60 kg P₂O₅ha⁻¹) at first cut and at harvest stages. This might be due to increased rate of light absorption, high photosynthetic activities and increased absorption of nutrients from the soil, Kajodmal (2004) [3].

Leaf area index was affected significantly at all the stages of crop growth due to cutting schedule. The maximum leaf area index was recorded under the treatment C1 (75 DAS) and C1 (45 DAS) at first cutting and final harvest stage respectively. It was possibly due to the better plant height, more number of leaves, maximum rate of light absorption, more absorption of nutrients from the soil because of more time duration availability for the regenerated crop after first cutting. Similar finding were reported by Manohar et al. (2017) [6].

The crude protein was recorded significantly maximum under the treatment F1 (120 kg N +60 kg P₂O₅ha⁻¹). This might be due to adequate nitrogen availability which contributed to increase more crude protein synthesis because of protein is made up of amino acid. So there is more formation of amino acid which results to more accumulation of crude protein in green fodder. The minimum crude protein was recorded under the treatment F1 (60 kg N +30 kg P₂O₅ha⁻¹) due to low accumulation of nitrogen in green fodder of barley, Ram et al. (2012) [8].

Crude protein was also significantly influenced by cutting schedule Table 2. The maximum crude protein was recorded under treatment C1 (45 DAS).The minimum crude protein was recorded under the treatment C4 (75 DAS) because of crude protein content was decreased due to higher fodder yield which lead to dilution of photosynthesates with the advancement of plant age. Midha (1994) [7].

The crude fiber was recorded significantly maximum under the treatment F1 (120 kg N +60 kg P₂O₅ha⁻¹). This might be due to adequate nitrogen and phosphorus availability which contributed to increase more crude fiber synthesis. The minimum crude fiber was recorded under the treatment F1 (60 kg N +30 kg P₂O₅ha⁻¹) due to low accumulation of fiber content in green fodder of barley Rawat (2011) [9].

Crude fiber was significantly affected by cutting schedule. The maximum crude fiber was recorded under treatment C4 (75 DAS) due to increases the fiber content in plant with advancement of plant age. The minimum crude fiber was recorded under the treatment C3 (45 DAS), Kaur et al. (2013) [4].

TDN was recorded significantly maximum under the treatment F1 (120 kg N +60 kg P₂O₅ha⁻¹) Table 2. This might be due to adequate nitrogen and phosphorus availability which improved the digestible quality of green fodder for improving in ether extract, crude protein, NDF and soluble carbohydrates. The minimum TDN was recorded under the treatment F1 (60 kg N +30 kg P₂O₅ha⁻¹) due to low availability of nitrogen and phosphorus to crop, Rawat (2011) [9].

The maximum TDN was recorded under treatment C4 (45 DAS) and minimum TDN was recorded under the treatment C3 (75 DAS) because of the TDN was decreased with the crop age advancement, Kaur et al. (2013) [4].

Various fertilizer levels and cutting schedule had significant influenced on water soluble carbohydrates. The water soluble carbohydrate was recorded significantly maximum when fertilizers supplied of 120 kg N +60 kg P₂O₅ha⁻¹. This might
be due to adequate nitrogen and phosphorus availability increased the water soluble carbohydrates in green fodder of barley. The minimum water soluble carbohydrates was recorded under the treatment F1 (60 kg N +30 kg P2O5 ha⁻¹) due to decreasing rate of nitrogen and phosphorus in comparison to other treatments. The maximum water soluble carbohydrate was recorded at 75 DAS and minimum at 45 DAS, because of the water soluble carbohydrates was increased with the crop age advancement. The acid detergent fiber was recorded significantly maximum with the application of 120 kg N +60 kg P2O5 ha⁻¹ presented in Table 2. This might be due to adequate nitrogen and phosphorus availability which increased the acid detergent fiber in green fodder of barley. The minimum acid detergent fiber was recorded under the treatment F1 (60 kg N +30 kg P2O5 ha⁻¹) due to decreasing rate of nitrogen and phosphorus in comparison to other treatments, Ayub et al. (2008).

Acid detergent fiber was also noted higher at 75 DAS and minimum at 45 DAS, because it increased with the crop age advancement due increasing the fibre content in plant, Midha (1994) [7]. The NDF was recorded significantly maximum under the treatment F4 (120 kg N +60 kg P2O5 ha⁻¹). This might be due to adequate nitrogen and phosphorus availability which increased the fibre content in green barely fodder. The minimum NDF was recorded under the treatment F1 (60 kg N +30 kg P2O5 ha⁻¹) due to decreasing rate of nitrogen and phosphorus in comparison to other treatments, Rawat (2011) [9]. The maximum NDF was recorded under treatment C3 (75 DAS) and minimum NDF was recorded under the treatment C1 (45 DAS) because it increased with the crop age advancement due increasing the fibre content in plant, Midha (1994) [7].

The total ash was recorded significantly maximum under the treatment F1 (60 kg N +30 kg P2O5 ha⁻¹) due to lower dry matter accumulation on per unit area which result more biomass production. The minimum total ash was recorded under treatment F1 (60 kg N +30 kg P2O5 ha⁻¹) due to lower dry matter accumulation on per unit area.

Total ash of barley were significantly influenced by cutting schedule. Significant effect of stage of harvesting on total ash percentage, with the advancements of the stage of harvesting total ash percentage was increased. Harvesting at 75 DAS produced highest total ash percentage which was significantly higher than 45 DAS and 55 DAS harvested crop. This result may be attributed to the increment of total ash percentage with increase in age of plants and 75 DAS harvested crop received more time from sowing to first cutting which achieved more growth than 45, 55 and 65 DAS crop.

Table 1: Plant height (cm), no of tillers (m⁻²) and dry weight of plants (gm⁻²) at different cutting stages of Barley crop as influenced by fertilizers and cutting schedule

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>No of tillers (m⁻²)</th>
<th>Dry weight of plants (g m⁻²)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>At first cutting</td>
<td>At harvest</td>
<td>At first cutting</td>
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<tr>
<td>fertilizers</td>
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<tr>
<td>60 kg N+ 30 kg P₂O₅ ha⁻¹</td>
<td>63.19</td>
<td>64.32</td>
<td>423.96</td>
</tr>
<tr>
<td>80 kg N+40 kg P₂O₅ ha⁻¹</td>
<td>64.31</td>
<td>66.60</td>
<td>439.8</td>
</tr>
<tr>
<td>100 kg N+50 kg P₂O₅ ha⁻¹</td>
<td>66.13</td>
<td>69.73</td>
<td>460.03</td>
</tr>
<tr>
<td>120 kg N+60 kg P₂O₅ ha⁻¹</td>
<td>67.03</td>
<td>71.34</td>
<td>471.21</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>2.73</td>
<td>3.53</td>
<td>36.86</td>
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</table>

<table>
<thead>
<tr>
<th>Cutting schedule</th>
<th>At first cutting</th>
<th>At harvest</th>
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</thead>
<tbody>
<tr>
<td>45 DAS</td>
<td>52.15</td>
<td>79.79</td>
</tr>
<tr>
<td>55 DAS</td>
<td>63.70</td>
<td>70.30</td>
</tr>
<tr>
<td>65 DAS</td>
<td>67.53</td>
<td>65.70</td>
</tr>
<tr>
<td>75 DAS</td>
<td>77.28</td>
<td>56.20</td>
</tr>
<tr>
<td>SE±</td>
<td>1.49</td>
<td>1.68</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>5.26</td>
<td>5.94</td>
</tr>
</tbody>
</table>

Table 2: Leaf area index, crude protein, crude fiber, TDN%, WSC%, ADF%, NDF% and Ash % of Barley crop as influenced by fertilizers and cutting schedule

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaf area index</th>
<th>Crude protein (%)</th>
<th>Crude fiber (%)</th>
<th>TDN (%)</th>
<th>WSC (%)</th>
<th>ADF (%)</th>
<th>NDF (%)</th>
<th>Ash (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>At First cutting</td>
<td>At harvest</td>
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<td></td>
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<tr>
<td>fertilizers</td>
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<td></td>
</tr>
<tr>
<td>60 kg N+ 30 kg P₂O₅ ha⁻¹</td>
<td>3.72</td>
<td>1.55</td>
<td>11.93</td>
<td>28.87</td>
<td>61.25</td>
<td>9.16</td>
<td>28.63</td>
<td>48.84</td>
</tr>
<tr>
<td>80 kg N+40 kg P₂O₅ ha⁻¹</td>
<td>3.86</td>
<td>1.67</td>
<td>12.03</td>
<td>29.36</td>
<td>62.52</td>
<td>9.44</td>
<td>29.52</td>
<td>50.11</td>
</tr>
<tr>
<td>100 kg N+50 kg P₂O₅ ha⁻¹</td>
<td>4.04</td>
<td>1.79</td>
<td>12.55</td>
<td>30.58</td>
<td>64.28</td>
<td>9.95</td>
<td>31.50</td>
<td>51.48</td>
</tr>
<tr>
<td>120 kg N+60 kg P₂O₅ ha⁻¹</td>
<td>4.14</td>
<td>1.83</td>
<td>12.88</td>
<td>31.87</td>
<td>65.93</td>
<td>10.04</td>
<td>31.74</td>
<td>52.49</td>
</tr>
<tr>
<td>SE±</td>
<td>0.08</td>
<td>0.07</td>
<td>0.23</td>
<td>0.52</td>
<td>0.87</td>
<td>0.19</td>
<td>0.55</td>
<td>0.82</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.33</td>
<td>0.22</td>
<td>0.69</td>
<td>1.50</td>
<td>2.60</td>
<td>0.56</td>
<td>1.62</td>
<td>2.42</td>
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<thead>
<tr>
<th>Cutting schedule</th>
<th>At first cutting</th>
<th>At harvest</th>
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<tbody>
<tr>
<td>45 DAS</td>
<td>3.2</td>
<td>1.90</td>
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<tr>
<td>55 DAS</td>
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<td>1.86</td>
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<td>65 DAS</td>
<td>4.3</td>
<td>1.70</td>
</tr>
<tr>
<td>75 DAS</td>
<td>4.4</td>
<td>1.39</td>
</tr>
<tr>
<td>SE±</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.27</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Conclusion
The maximum green fodder yield, grain and straw yield as well as various quality parameters were recorded with the application of 120 kg N +60 kg P₂O₅ ha⁻¹ and at first cutting (75 DAS) while the crude protein% and TDN % were found maximum at first cutting (45 DAS).

References