GROWTH OF RAINFED FODDER MAIZE UNDER DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS

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ABSTRACT:- Maize fodder yield was determined under various nitrogen and phosphorus doses under sub-humid rainfed conditions during 2009 at PMAS-Arid Agriculture University, Rawalpindi, Pakistan. The annual rainfall at the experimental site during 2009 was 685.9 mm. The experimental soil was of loamy texture having E.C. of 0.48 $dscm^{-1}$, pH 7.7, organic matter 0.65%, saturation 30%, available phosphorus 5.7 mg kg^{-1} and available potassium 78 mg kg^{-1}. Maize cv. Sargodha-2002 was sown in randomized complete block design (factorial) and was fertilized with four each nitrogen @ 0, 60, 120 and 180 kg ha^{-1} and phosphorus 0, 30, 60 and 90 kg ha^{-1} doses. Significant increase in green fodder and dry matter yield was observed with the increased doses of nitrogen and phosphorus. Overall, the nitrogen application @ 180 kg ha^{-1} increased the green fodder and dry matter yield by 12.33% and 51.50%, respectively. Similarly, with phosphorus application @ 90 kg ha^{-1}, the 36.80% and 46.26% increase was observed in green fodder and dry matter yield, respectively. In combination of nitrogen and phosphorus @ 180:90 NP kg ha^{-1}, there was a significant increase in green fodder and dry matter yields through their interactive effect, that were 90.19% and 159.31%, respectively. This increase may be due to increase in vegetative growth parameters like plant height, stem diameter and leaf area. It was concluded that fertilizers combination of 180:90 NP kg ha^{-1} was recommended for obtaining higher maize fodder yield under rainfed conditions of Rawalpindi, Pakistan.

Key Words: Maize; Fodder; Growth; Nitrogen; Phosphorus; Crop Yield; Pakistan.

INTRODUCTION

In Punjab, located at north east of Pakistan (coordinates 31.33°N 74.21°E), around 20% of rainfed land is under forage which supports about 70% of dairy population in the peri-urban region. Out of total cropped area of 23.51 mha, only 2.35 mha is under fodder crops in Pakistan (GoP, 2011). Green fodder is the most valuable and cheapest source of food for the livestock. It is very rich source of energy, nutrient elements, carbohydrates, proteins and water. Fodder shortage is the major limiting factor for livestock production in rainfed areas of our country. Maize is grown all over the country and covers about 4.8% of the total cropped area. The nutritious fodder is relished by all kinds of livestock, especially milch animals. It is most important constituent of cattle fodder and poultry feed (Younas and Yaqoob, 2005).

The soil and climatic conditions of Pakistan are favorable for maize fodder production but our fodder yield per unit area is still very

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low as compared to other maize growing countries due to many production constraints. Fertilizer application with optimum doses is considered one of the major factors which can enhance the fodder production. Pakistan soils are deficient in nitrogen (N) and phosphorus (P) but the status of potassium (K) is variable (NFDC, 2003). Nitrogen promotes rapid vegetative growth and increases crop yields. The green fodder yield was significantly promoted with increased nitrogen levels (Ayub et al., 2003). Phosphorus plays a major role in photosynthesis and stimulates early growth and root formation so considered an essential nutrient for plant growth and development. Phosphorus increases fodder yield and quality by increasing plant height, leaves plant^{-1}, crude protein and ash content (Cheema, 2000).

Amongst the essential plant nutrients, N and P are often the most important determinants of plant growth and crop yield. Nitrogen is one of the critical nutrients for crop production and is generally applied in large quantities in the form of fertilizer to soils. However, most of the plants only utilize less than one-half of applied N fertilizer, and there is a great loss of N fertilizer through leaching and volatilization. Generally, our soils are calcareous in nature, P is most susceptible to fixation, and the crops usually recover less P in the short term than other nutrients. The nitrogen and phosphorus being major macronutrients are the integral components of the chlorophyll, ATP, enzymes and nucleic acids and has vital role in metabolic activities and cellular respiration (Li et al., 2011). Therefore, N and P application promotes not only growth characteristics (plant height, leaves per plant, stem diameter, leaf area, green fodder yield and dry matter percentage) but also enhance quality parameters (crude protein, crude fiber and total ash contents) (Ayub et al., 2002).

Keeping in view the importance of nitrogen and phosphorus, different experiments have been conducted to enhance maize fodder in the irrigated areas, but less attention has been paid to the rainfed and sub-humid areas of Pakistan. The present research was therefore designed, to assess the effects of different doses of nitrogen and phosphorus separately and in combination, on yield and other yield components of rainfed maize forage to standardize balanced nutrition under sub-humid climatic conditions of Rawalpindi, Pakistan.

MATERIALS AND METHOD

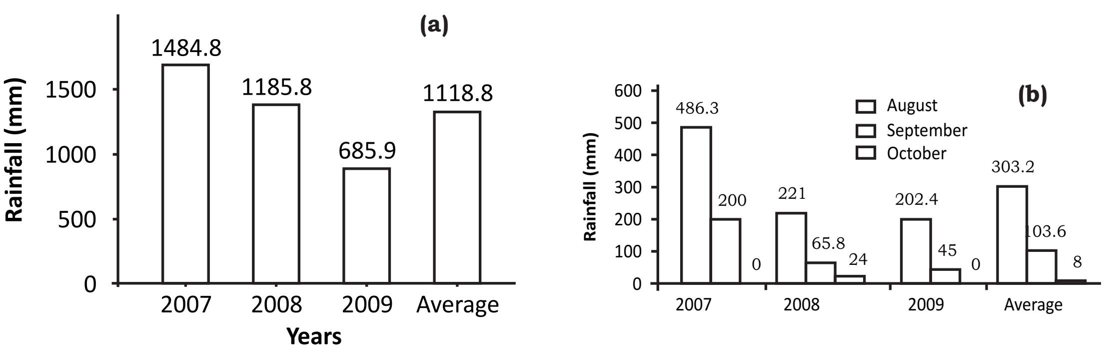
The experiment was conducted on loamy soil of series Rajar allowing roots to penetrate deep enough, EC 0.48 dscm^{-1}, pH 7.7, organic matter 0.65%, saturation percentage 30%, available phosphorus 5.7 mg kg^{-1} and available potassium 78 mg kg^{-1} to evaluate yield and yield components of maize fodder with various nitrogen and phosphorus levels under rainfed conditions during 2009 at PMAS-Arid Agriculture University, Rawalpindi, Pakistan coordinates 33°36'0"N 73°02'0"E, elevation 500 m above sea level located in the north west of Pakistan. The annual rainfall (Figure 1 a) at the experimental site during 2007, 2008 and 2009 was

1484.8 mm, 1185.8 mm and 685.9 mm, respectively. The maize cv. Sargodha-2002 seed was obtained from National Agricultural Research Centre (NARC) Islamabad and was sown on August 25, 2009 in 30 cm apart rows with single row hand drill and harvested at 50% flowering stage. It was planted in 16 plots with four doses each of nitrogen and phosphorus fertilizers. The net plot size was 1.8 m x 4 m for each treatment. The NP fertilizers in the form of urea and triple super phosphate were applied at the time of sowing in following 16 N and P combinations i.e., 0:0, 0:30, 0:60, 0:90, 60:0, 60:30, 60:60, 60:90, 120:0,120:30,120:60, 120:90, 180:0, 180:30, 180:60, 180:90 kg ha^{-1}. For recording plant density, total number of plants was counted in 1m^2 at three randomly selected places in each plot and their averages were calculated. Ten plants were selected at random in each plot to record individual observations of plant height, stem diameter, leaves per plant and leaf area per plant. Plant height was taken from the ground level up to the highest leaf tip with the help of a measuring rod. Stem diameter was measured from top, middle and bottom portions of plant with Vernier Calliper and then averages were calculated. The meteorological data (Table 1 and Figure 1) was obtained from Pakistan Meteorological Department (PMD), Regional Agro-met Center, Rawalpindi, Pakistan located around 300m away from experimental plot. All the data were analyzed according to Steel and Torrie (1980) and Duncan's Multiple Range Test (DMRT$_{0.05}$) was applied to separate and compare the means.

Table 1. Monthly meteorological data of the study area

Month	Total rainfall (mm) in 2009	Average rainfall (mm) of 3 years	Mean temperature (°C) in 2009	Average temperature (°C) of 3 years	Relative humidity in 2009	Average relative humidity of 3 years
August	202.4	303.2	29.2	28.5	68.3	71.03
September	45.0	103.6	27.6	26.5	59.9	59.87
October	Traces	8.0	23.1	22.7	54.9	56.03

Source: *Pakistan Meteorological Department (PMD), Regional Agro-met Center, Rawalpindi*



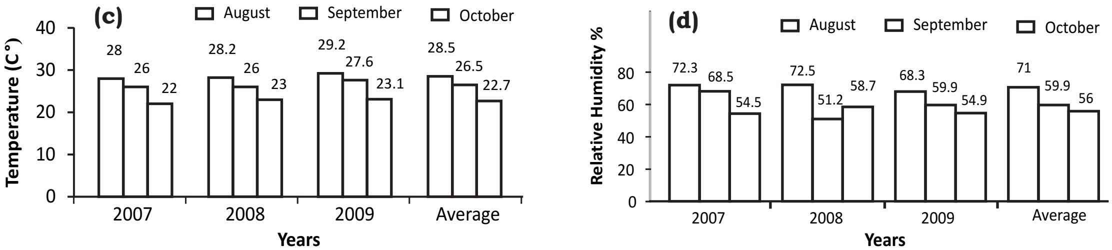


Figure 1. Three years (a) annual rainfall, (b) monthly rainfall (mm), (c) temperature (°C) and (d) relative humidity (%) data of the study area

RESULTS AND DISCUSSION

Plant Density

To obtain higher yield of the fodders, optimum plant population is the key factor. Data regarding plant density revealed that nitrogen levels higher than the recommended dose @ 60 kgha^{-1} has adversely affected the plant density (Table 2) which are contradictory to the findings of Ayub et al. (2002b) which may be due to phytotoxic effect of higher dose of nitrogen to the emerging plumules or ex-osmosis from seeds by higher dose of nitrogen. However, the phosphorus alone and interaction of nitrogen and phosphorus showed non-significant mean differences which are quite in line with those of Ahmad et al. (2007) and Loecke et al. (2004) and reported non-significant effect of nitrogen and phosphorus on the plant density.

Plant Height

Data related to plant height manifested that nitrogen and phosphorus application significantly affected the plant height (Table 2). The maximum (117.78 cm) and minimum (103.17 cm) plant height was recorded with nitrogen @ 180 kgha^{-1} and control, respectively. Results are in corroboration with those of Agha et al. (1981) Saeed et al. (2001) Keskin et al. (2005) Karasu et al. (2009) Nadeem et al. (2009) Onsanya et al. (2009) and Aslam et al. (2011) who reported that plant height was increased due to increased levels of nitrogen. While regarding phosphorus, maximum (120.86 cm) and minimum (95.76 cm) plant height was recorded with phosphorus @ 90 kg ha^{-1} and control, respectively. Similar results have also been obtained by Karadag and Buyukburc (2001), Masood et al. (2011) and Rashid and Iqbal (2012)

Table 2. Effect of different doses of nitrogen and phosphorus on plant density, plant height and leaves per plant of maize fodder

Treatment	Plant density (m^{-2})	Plant height (cm)	No. of leaves per plant
Nitrogen (kgha^{-1})			
0 (N1)	22.28a	103.17b	12.73 NS
60 (N2)	22.83a	105.83b	12.74
120 (N3)	6.84b	113.34ab	13.00
180 (N4)	13.67b	117.78a	13.15
Phosphorus (kgha^{-1})			
0 (P1)	18.78 NS	95.76c	12.40b
30 (P2)	19.31	107.85b	12.56b
60 (P3)	18.47	115.66ab	13.13a
90 (P4)	19.06	120.86a	13.53a

Means followed by same letter do not differ significantly at P=0.05.

who reported that plant height was significantly affected by phosphorus. The increase in plant height might be due to increasing level of nitrogen and phosphorus as it enhances cell division, cell elongation and nucleus formation. The mean values having interaction between phosphorus and nitrogen levels exhibited non-significant differences for plant density, plant height and leaves per plant.

Leaves per plant

The nitrogen application and interaction between nitrogen and phosphorus did not significantly affect the leaves per plant which are same as the findings of Karasu et al. (2009) and Aslam et al. (2011) who found no significant relationship between nitrogen and leaves per plant. However, Saeed et al. (2001) Nadeem et al. (2009) and Onsanya et al. (2009) mentioned that nitrogen and interaction of nitrogen and phosphorus increased the leaves per plant. The leaves were significantly affected by phosphorus application. The maximum (13.53) and minimum (12.40) leaves per plant were recorded with phosphorus @ 90 kg ha^{-1} and control, respectively. Similar results have been obtained by Chaudhry and Khade (1991), Cheema (2000), Saeed et al. (2001) and Onsanya et al. (2009) and mentioned that number of leaves were increased with increased application of phosphorus.

Stem Diameter

The nitrogen, phosphorus and their interaction significantly affected the stem diameter (Table 3). The maximum stem diameter (1.34 cm) was obtained with the appli-cation of 180 $kgNha^{-1}$ while minimum value for stem diameter (1.05 cm) was obtained in control. Positive correlation between nitrogen levels and stem diameter have been reported by Safdar (1997), Cho et al. (2001) Nadeem et al. (2009) and Aslam et al. (2011). However, our results were contradictory with the findings of Karasu et al. (2009) who reported that stem diameter was not affected by nitrogen applications. In phosphorus, maximum stem diameter (1.46 cm) was produced with phosphorus @ 90 $kgha^{-1}$ and it was followed by 60 $kgPha^{-1}$ (1.17 cm). Minimum stem diameter (1.095 cm) was produced in control where no phosphorus was applied. These results are quite in line with those of Karadag and Buyukburc (2001) as they also reported that increase phosphorus also promote the stem diameter. The interaction of N and P was found significant, and maize sown with 60:0 NP $kgha^{-1}$ provided maximum stem diameter (1.70 cm) and was at par with NP@ 0:90 kg ha^{-1}, whereas the control produced minimum stem diameter (0.85 cm) and was at par with 0:30 NP kg ha^{-1}.

Leaf Area per Plant

It was significantly affected by nitrogen application (Table 3). The application of nitrogen @ 180 $kgha^{-1}$ produced maximum leaf area per plant (2806 cm^2) followed by 120 kg N ha^{-1} (2611 cm^2). The minimum leaf area per plant (2268 cm^2) was observed with no application of nitrogen and was found similar to nitrogen application @ 60 $kgha^{-1}$ (2281 cm^2). Similar results have been reported by Tariq et al. (1998), Saeed et al. (2001), Onsanya et al. (2009), Nadeem et al. (2009) and Aslam et al. (2011) who mentioned that more the

Table 3. Effect of various doses of nitrogen and phosphorus on stem diameter, leaf area per plant, green fodder yield, dry matter yield and dry matter content of maize fodder

Treatment	Stem diameter (cm)	Leaf area/plant (cm^2)	Green fodder yield (th^a)	Dry matter yield (th^{a-1})	Dry matter contents (%)
Nitrogen (kg ha^{-1})					
0 (N_1)	1.05^d	2268^c	24.89^b	4.33^c	18.95^d
60 (N_2)	1.16^c	2281^c	25.09^b	4.37^c	19.56^c
120 (N_3)	1.29^b	2611^b	26.22^b	6.08^b	20.72^b
180 (N_4)	1.34^a	2806^a	27.96^a	6.56^a	21.69^a
Phosphorus (kg ha^{-1})					
0 (P_1)	1.095^d	2227^d	21.36^c	4.15^c	18.94^d
30 (P_2)	1.113^c	2356^c	24.46^b	5.31^b	19.54^c
60 (P_3)	1.17^b	2628^b	29.11^a	5.84^a	20.41^b
90 (P_4)	1.46^a	2754^a	29.22^a	6.07^a	22.03^a
Nitrogen x Phosphorus levels (kg ha^{-1})					
N_1P_1	0.85^m	1966^l	18.45^i	3.17^j	17.21^l
N_1P_2	0.85^m	2302^{hi}	23.71^{fgh}	4.42^{fghi}	18.27^{jk}
N_1P_3	0.88^l	2566^{def}	32.5^{ab}	4.62^{fghi}	18.45^{jk}
N_1P_4	1.60^a	2236^i	24.88^{efg}	5.11^{efg}	21.88^{cd}
N_2P_1	1.70^a	2027^{kl}	20.84 ^{hi}	3.74^{ij}	19.99^k
N_2P_2	1.09^j	2102^{jk}	25.34^{efg}	4.12^{hi}	18.69^j
N_2P_3	1.20^h	2185^{ij}	23.98^{fg}	4.34^{ghi}	19.26^i
N_2P_4	1.28^f	2808^c	30.18^{bc}	5.29^{def}	22.3^{bc}
N_3P_1	1.23^g	2389^{gh}	22.57^{gh}	4.73^{fgh}	19.69^{hi}
N_3P_2	1.17^i	2440^{fg}	24.04^{fgh}	6.61^{bc}	20.07^{gh}
N_3P_3	1.28^f	3139^b	31.53^{abc}	7.34^b	22.58^b
N_3P_4	1.48^b	2477^{efg}	26.74^{def}	5.65^{de}	20.53^{fg}
N_4P_1	1.23^g	2525^{def}	23.57^{fgh}	4.91^{efgh}	20.85^{ef}
N_4P_2	1.34^d	2581de	24.75^{efgh}	6.07^{cd}	21.14^e
N_4P_3	1.32^e	2620^d	28.43^{cde}	7.04^b	21.36^{de}
N_4P_4	1.46^c	3496^a	35.09^a	8.22^a	23.41^a

Means followed by same letter do not differ significantly at P = 0.05

amount of nitrogen applied to a certain level, the more will be the leaf area per plant. Leaf area per plant was significantly affected by phosphorus application. The phosphorus @ 90 kgha^{-1} produced highest leaf area per plant (2754 cm^2) followed by 60 kg P ha^{-1} (2628 cm^2). The minimum leaf area per plant (2227 cm^2) was observed without phosphorus application and was significantly less than the leaf area obtained with phosphorus application @ 30 kgPha^{-1} (2356 cm^2). Results followed the findings of Chaudhry and Khade (1991) and Saeed et al. (2001) as they also noted that phosphorus was in direct relationship with leaf area per plant. Interaction between two factors was also significant. The maximum (3496 cm^2) and minimum (1966 cm^2) leaf area per plant was observed with 180:90 NP $kgha^{-1}$ and control, respectively.

Green Fodder Yield

Data regarding green fodder yield exhibited that fodder yield was significantly affected by different levels of nitrogen and phosphorus (Table 3, Figure 2). The maximum (27.96 t ha^{-1}) and minimum (24.89 tha^{-1}) green fodder yield was observed with nitrogen application @ 180 kg ha^{-1} and control, respectively. The increase in yield with increase in nitrogen level was mainly associated with increased plant height, leaves per plant and stem diameter. Same findings have been reported by Rafi (tha^{-1}) et al. (1996), Saeed et al. (2001), Ayub et al. (2002 a&b), Karasu et al. (2009) and Aslam et al. (2011) as they also observed that with higher doses of nitrogen the green fodder yield was also increased. The green fodder yield also enhanced with increased phosphorus, and maxi-mum (29.22 tha^{-1}) and minimum (21.36 tha^{-1}) green fodder yield was observed with phosphorus @ 90 kg P ha^{-1} and control, respectively. The results are quite in line with those of Karadag and Buyukburc (2001), Saeed et al. (2001) and Rashid and Iqbal (2012) as they also noted that higher phosphorus application also increases green fodder yield. The interaction (P x N) was also significant and the maximum (35.09 tha^{-1}) and minimum (18.45 tha^{-1}) green fodder yield was observed with 180: 90 NP $kgha^{-1}$ and control, respectively which are similar to the findings observed by Saeed et al. (2001).

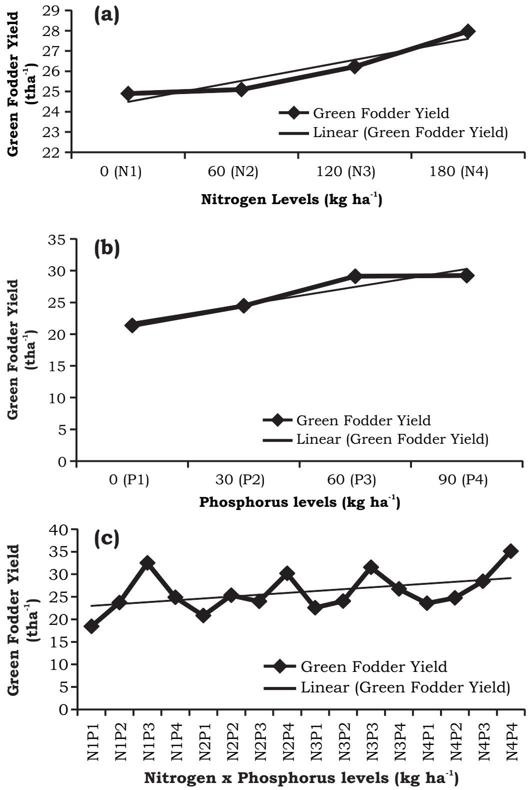


Figure 2. Effect of different levels of (a) nitrogen, (b) phosphorus and (c) nitrogen x phosphorus on green fodder yield (t ha^{-1}) of maize fodder

Dry Matter Yield

It was significantly affected by both nitrogen and phosphorus applications (Figure 3). The maximum (6.56 t ha^{-1}) and minimum (4.33 t ha^{-1}) dry fodder yield was observed with nitrogen application @ 180 kg ha^{-1} and control, respectively. Saeed et al. (2001) Ayub et al. (2002 a&b), Hani et al. (2006), Karasu et al. (2009) Nadeem et al. (2009) and Aslam et al. (2011) have also reported increased dry matter yield with nitrogen application. With phosphorus maximum (6.07 tha^{-1}) and minimum (4.15 t ha^{-1}) dry fodder yield was observed with 90 $kgha^{-1}$ and control, respectively.

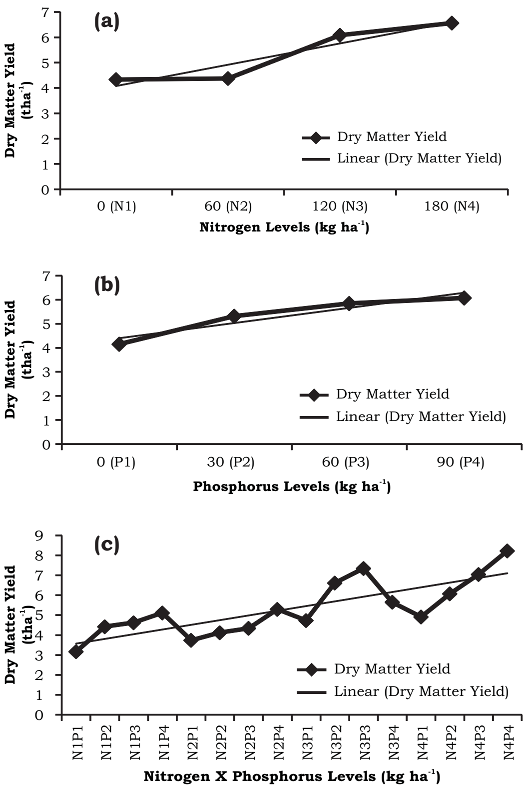


Figure 3. Effect of different levels of (a) nitrogen, (b) phosphorus and (c) nitrogen x phosphorus on dry matter yield (t ha^{-1}) of maize fodder

These results are in line with Saeed et al. (2001) and Rashid and Iqbal (2012) as they also found increased dry matter with increased level of phosphorus; but in contrast with those of Hani et al. (2006) who reported that higher phosphorus levels have non-significant effect on dry matter production. Interaction between nitrogen and phosphorus levels was also significant. All the phosphorus levels performed significantly different in combination with nitrogen @ 180 N kgha^{-1}. The maximum (8.22 t ha^{-1}) and minimum (3.17 tha^{-1}) dry matter yield was observed with 180:90 NP kgha^{-1}and control, respectively. The results are quite in line with those of Saeed et al. (2001) who also reported significant increase in dry matter yield with combined application of nitrogen and phosphorus.

Dry Matter Content

The dry matter percentage was significantly affected by various nitrogen levels (Table 3). There has been gradual increase in dry matter percentage with increase in nitrogen doses. The maximum (21.69%) and minimum (18.95%) dry matter percentage was recorded with nitrogen @ 180 kgha^{-1} and control, respectively. These results conform those of Ayub et al. (2002, 2003) who also mentioned that nitrogen has synergistic effect on dry matter content production in fodders. There was a significant increase in dry matter percentage with increase in phosphorus doses too. The maximum (22.03%) and minimum (18.94%) dry matter percentage was recorded with phosphorus @ 90 kg ha^{-1} and control, respectively. The interaction between nitrogen and phosphorus doses was also significant. All the nitrogen levels differed significantly when phosphorus was applied @ 60 kg P ha^{-1}. The maximum (23.41%) and minimum (17.21%) dry matter percentage was observed with NP @ 180:90 kg ha^{-1}and control, respectively.

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