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INTERACTIVE EFFECT OF DIFFERENT NITROGEN LEVELS AND SEED RATES ON YIELD AND YIELD ATTRIBUTES OF FODDER MAIZE (*Zea mays* L.) UNDER TEMPERATE CONDITIONS OF KASHMIR

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ABSTRACT

Two year field studies were conducted at Experimental Farm, SKUAST-Kashmir to evaluate the effect of 60, 90 and 120 kg N ha^{-1} on fodder maize sown at seeding rate of 40, 60 and 80 kg ha^{-1}. Application of 120 kg N ha^{-1} significantly increased green and dry fodder yields of maize due to increase in all yield components studied viz., plant height, leaf area index, dry matter production and stem diameter. Seed rate of 60 and 80 kg ha^{-1}, being at par, significantly increased plant height and dry matter over 40 kg seed rate ha^{-1}, whereas, leaf area index recorded significantly higher values up to 80 kg seed rate ha^{-1}. Stem diameter recorded significantly lower values with increasing seed rates but green and dry fodder-yield values were realized statistically higher up to 80 and 60 kg seed rate ha^{-1}, respectively. Fodder maize sown at seed rate of 80 kg ha^{-1} and receiving 120 kg N ha^{-1} seems to be the best combination in getting maximum green, succulent and palatable fodder under temperate conditions of Kashmir.

Keywords: Fodder maize, interaction effect, nitrogen, seed rate, temperate, yield attributes

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important dual crops grown widely in *Kharif* season for both grain and fodder. The crop has an edge over other cultivated fodder crops due to its high production potential ability, wider adaptability, quick growing nature, succulence, palatability, excellent fodder quality and free from toxicants. It can be safely fed to animals at any stage of crop growth and requires less labour and machinery than other forage crops (Roth *et al*., 1995). Maize is highly exhaustive crop, depletes the soil of its nutrients and therefore needs good nutrient management. Poor nutrient management in fodder maize is one of the constraints for its low productivity. Nitrogen fertilization influences forage growth. The optimum use of nitrogen fertilization in forage maize depends on various variable factors such as environmental conditions, management followed and genotype used. Nitrogen fertilization affects dry matter yield of maize by influencing leaf area index, leaf area duration, photosynthetic efficiency, plant height, etc. (Keskin *et al*., 2005; Carpici *et al*., 2010). O'Leary and Rehm (1990) reported that forage maize dry matter yield responded linearly to nitrogen rates at three sites and curvilinear at five sites. Nitrogen application significantly increases the yield components viz., plant height, leaf area index, stem diameter, etc. and thereby enhances forage yield (Sharma, 2009; Almodares *et al.,* 2009; Osman *et al.,* 2010; Valadabadi and Farhani, 2010).

Maize is more sensitive to the variations in plant density than other crops of grass family (Almeida

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and Sangoi, 1996). Plant density affects yield and other important agronomic attributes of the crop. Crop stand density affects plant architecture, alters growth and developmental patterns, and influences carbohydrate production and partitioning (Sangoi, 2000). Forage maize responds variably to plant densities under different environmental and cultural factors which influence maize forage yield. The relationship between maize forage yield and plant density is not well established. Reports revealed that total dry matter enhances from 6 to 40% when plant density increases from about 55,000 to 88,000 plants ha^{-1} (Sarvestani *et al*., 2001; Berzsenyi and Lap, 2005) and 79,000 to 165,000 plants ha^{-1} in some other studies (Turgut *et al*., 2005; Yandim, 2006; Yilmaz *et al*., 2007). Many researchers found that increasing seed rate up to 75 kg ha^{-1} significantly tended to produce higher fodder yield due to increase in plant height, leaf area index and unit area leaf number (Malik *et al.*, 2007; Tiwana *et al*., 2007; Pradhan *et al*., 2009). In view of above the present study was conducted to optimize seed rate and nitrogen dose for higher fodder yield of maize under temperate agro-climatic conditions of Kashmir.

MATERIALS AND METHODS

Field studies were conducted during the *Kharif* seasons of year 2009 and 2010 at Experimental Farm, Division of Agronomy, SKUAST-Kashmir, situated at 34^{0}8`N and 74$^0$83`E. Climatically, the experimental site is located in mid-high altitude temperate zone, characterized by hot summers and severe cold winters. The soil of the experimental site was silty clay loam in texture, low in available nitrogen (265.31 kg ha^{-1}) and zinc (0.51 ppm) and medium in available potassium (163.0 kg ha^{-1}) and phosphorus (15.1 kg ha^{-1}) with neutral pH (6.8). The maize variety J-1006 was used as experimental material. Three nitrogen levels (60, 90 and 120 kg ha^{-1}) and three seed rates (40, 60 and 80 kg ha^{-1}) were evaluated in randomized block design with each treatment replicated three times. Half dose of nitrogen (as per treatment) and full dose of P and K (recommended) was applied as basal before sowing to each plot. Remaining half dose of nitrogen was top dressed at knee high stage after first irrigation. Pre-soaked maize seed was sown manually on 25 June 2009 and 26 June 2010 at row spacing of 45 cm and depth of 4-5 cm in each plot. The crop was harvested at 75% silking. The plant height of five randomly tagged plants in the penultimate rows of each plot was recorded at harvest. Leaf area index was recorded with canopy analyzer (Accu PAR Model LP-80). Plant samples from 50 cm row length at marked spot in each plot were harvested, chopped, sun dried for 2 days and then oven-dried at 65^{0}C to constant weight for dry matter yield estimation. Stem diameter was measured with the help of a vernier caliper from top, middle and bottom portions of the stem. At maturity, plants from net area were cut and weighted. The fresh weight was then air-dried to determine the dry weight. The data was statistically analyzed as per the method of Cochran and Cox (1963). The meteorological data with respect to temperature, relative humidity and precipitation during the cropping period of both the years was recorded.

RESULTS AND DISCUSSION

Most of the precipitation during cropping seasons was received from December to April in the form of either snow or rain. From the mean meteorological data for cropping seasons recorded, the mean maximum and minimum temperature was 27.79 and 26.9°; and 12.0 and 11.20°C during the cropping seasons of 2009 and 2010, respectively. Maximum and minimum relative humidity was 83.49, 82.74 and 59.34 and 56.76% during both the cropping seasons, respectively. Precipitation patterns and amount differed markedly between both growing seasons. The cumulative precipitation was 177.0 and 249.7 mm during 2009 and 2010 respectively.

Yield attributes

The nitrogen application significantly increased plant height ranging from 213.9 to 221.9 cm (Table 1), which may be attributed to the positive effect of nitrogen on plant vegetative growth that led to the progressive increase in internodes length. These results corroborate with Eltelib *et al*. (2006). The plots with seed rate of 60 and 80 kg ha^{-1}, being at par, recorded significantly taller plants than plots sown at 40 kg seed rate ha^{-1}. Increase in plant height with increasing seed rates may be due to competition for light. Further, basipetal movement of auxins and shading effect may have induced the auxins to move from illuminated side to shade side. The imbalance of auxin might cause more elongation of plants in shade with curvature compared to being in light. Since auxin is sensitive to light, shading prevents its destruction and thus higher accumulation of auxin in shady plants triggers increase in its height. The results are in conformity with Joshi and Kumar (2007) and Ramezani *et al*. (2011).

Table 1: Effect of nitrogen and seed rate on plant height, leaf area index and dry matter of fodder maize during the two cropping seasons

Treatments	Plant height (cm)		Leaf area index		Dry matter (q ha^{-1})	
	2009	2010	2009	2010	2009	2010
Nitrogen levels (kg ha^{-1})						
N_{60}	213.9	214.2	5.26	5.29	104.7	105.2
N_{90}	217.1	217.5	5.90	5.91	112.0	112.4
N_{120}	221.9	222.3	6.30	6.32	114.7	115.2
SEm±	0.40	0.38	0.12	0.13	0.78	0.33
$CD_{0.05}$	1.16	1.10	0.36	0.38	2.26	0.95
Seed rate (kg ha^{-1})						
S_{40}	216.0	217.0	4.60	4.63	107.2	106.8
S_{60}	218.0	218.4	5.90	5.91	111.9	112.8
S_{80}	218.6	218.6	6.90	6.92	112.3	113.2
SEm±	0.40	0.38	0.12	0.13	0.78	0.33
$CD_{0.05}$	1.16	1.10	0.36	0.38	2.26	0.95
Interaction effect						
N_{60} x S_{40}	212.3	213.0	4.06	4.49	101.0	101.0
N_{60} x S_{60}	213.3	216.6	5.36	5.13	108.5	107.2
N_{60} x S_{80}	216.2	221.3	6.36	6.26	111.5	107.4
N_{90} x S_{40}	215.5	214.8	4.70	5.49	106.2	108.2
N_{90} x S_{60}	217.5	217.9	6.00	6.11	113.9	114.4
N_{90} x S_{80}	218.2	222.6	7.00	6.14	116.1	114.6
N_{120} x S_{40}	220.5	215.5	5.10	5.90	106.5	111.2
N_{120} x S_{60}	223.5	218.0	6.40	6.50	114.3	116.9
N_{120} x S_{80}	221.6	223.0	7.40	6.54	116.5	117.6
SEm±	0.69	0.65	0.02	0.22	1.35	0.57
$CD_{0.05}$	2.0	1.90	0.62	0.65	3.91	1.64

The interaction between nitrogen doze and seed rate was significant. The taller plants of 223.5 and 223.0 cm were recorded in treatment combinations N_{120} x S_{60} and N_{120} x S_{80} during 2009 and 2010 (Table 1). Leaf area showed significant increase with increase in nitrogen level up to 120 kg ha^{-1} (Table 1). In fact N at higher rates tended to produce more proteins and induced vegetative growth which resulted in increase in photosynthetic surface that stimulated more leaf length, width and blade size. Osman *et al*. (2010) reported similar findings. Leaf area index showed significant and consistent improvement with increase in seed rate from 40 to 80 kg ha^{-1} (Table 1). This could be attributed to higher plant density that corresponds to higher cumulative leaf area. These results are in agreement with Valadabadi and Farahani (2010) but contradict with Ayub *et al*. (2007) who realized decrease in leaf area index with increase in plant density. The significantly high leaf area index of 7.40 and 6.54 was recorded in treatment combination N_{120} x S_{80} during 2009 and 2010, respectively (Table 1). Dry matter accumulation showed significantly consistent increase with increase in nitrogen dose up to 120 kg ha^{-1}

(Table 1). Higher dry matter accumulation observed at higher nitrogen rates could be attributed to the production of taller plants, increased photosynthetic area (LAI) and stem diameter that seem to have paved the way for more production of photosynthetic dry matter. Patel *et al*. (2006) reported significant increase in dry matter production of fodder maize with nitrogen application at 175 kg ha^{-1} as against lower levels viz., 150, 125, 100 and 75 kg N ha^{-1}. Dry matter was significantly influenced by varying seed rates. The seed rate of 60 and 80 kg ha^{-1} recorded significantly higher dry matter than 40 kg ha^{-1} (Table 1). The dry matter production is related to the amount of solar radiation intercepted by the canopy. As the canopy expands rapidly, more radiation is intercepted and more dry matter is produced. Similar, findings have been reported by Yalmaz *et al*. (2007) and Valadabadi and Farhani (2010).

The interaction effect on dry matter production was significant. The highest dry matter production of 116.5 and 117.6 q ha^{-1} was observed in treatment combination N_{120} x S_{80} during 2009 and 2010, respectively, but was at par with N_{120} x S_{60}, N_{90} x S_{80} and N_{90} x S_{60} in 2009 and with N_{120} x S_{60} in 2010 (Table 1). Stem diameter showed significant but consistent increase with enhancement in nitrogen dose from 60 to 120 kg ha^{-1} (Table 2) which could be attributed to more cell division and protein synthesis at higher rates of nitrogen. Similar results have been reported by Eltelib (2006) and Ayub *et al*. (2007). Stem diameter values registered significant decreasing trend with increase in seed rates up to 80 kg ha^{-1} (Table 2), which might have occurred due to severe competition at higher plant density. Ayub *et al*. (2007) also reported that stem diameter of pearl millet decreased from 0.86 to 0.72 cm with increase in seed rate from 10 to 20 kg ha^{-1}. Significantly highest stem diameter of 2.26 and 2.24 cm was recorded in treatment combination N_{120} x S_{40} during both the years (Table 2). The stem diameter increased significantly with increase in nitrogen dose but decreased with increase in seed rate.

Table 2: Effect of nitrogen and seed rate on stem diameter and green and dry fodder yield of maize during the two cropping seasons

Treatments	Stem diameter (cm)		Green fodder yield (q ha^{-1})		Dry fodder yield (q ha^{-1})	
	2009	2010	2009	2010	2009	2010
Nitrogen levels (kg ha^{-1})						
N_{60}	1.81	1.83	401.1	400.9	106.8	106.9
N_{90}	1.90	1.91	432.3	433.0	114.8	114.3
N_{120}	2.10	2.10	440.0	441.8	117.1	118.4
SEm±	0.01	0.02	0.88	0.91	0.74	0.83
$CD_{0.05}$	0.04	0.06	2.54	2.63	2.15	2.40
Seed rate (kg ha^{-1})						
S_{40}	2.01	2.02	404.5	405.2	108.5	108.6
S_{60}	1.93	1.94	430.6	431.4	114.8	115.3
S_{80}	1.87	1.88	438.4	439.3	115.4	115.8
SEm±	0.01	0.02	0.88	0.91	0.74	0.83
$CD_{0.05}$	0.04	0.06	2.54	2.63	2.15	2.40
Interaction effect						
N_{60} x S_{40}	1.83	1.87	375.3	379.8	102.3	102.2
N_{60} x S_{60}	1.81	1.83	404.8	407.1	108.7	109.0
N_{60} x S_{80}	1.76	1.79	423.5	416.2	109.3	109.5
N_{90} x S_{40}	1.94	1.95	414.5	416.1	110.3	109.7
N_{90} x S_{60}	1.90	1.91	438.9	437.5	116.7	116.3
N_{90} x S_{80}	1.87	1.87	443.6	445.7	117.3	116.8
N_{120} x S_{40}	2.26	2.24	423.7	419.8	112.7	113.8
N_{120} x S_{60}	2.05	2.08	448.2	449.7	119.0	120.4
N_{120} x S_{80}	1.98	1.98	448.2	456.1	119.6	120.9
SEm±	0.02	0.03	1.52	1.58	1.29	1.44
$CD_{0.05}$	0.06	1.10	4.40	4.55	3.72	4.15

Yield

Fresh green and dry fodder yield of maize during both years of 2009 and 2010 recorded significant and consistent increase with increase in nitrogen rate from 60 to 120 kg ha^{-1} (Table 2). Since nitrogen is an essential constituent of plant tissue and is involved in cell division and cell elongation, its beneficial effect on growth characters viz., plant height, leaf area index and stem diameter might have contributed to the higher yield. Keskin *et al.* (2005) and Almodares *et al*. (2009) have reported significant increase in green and dry fodder yield of corn with increase in nitrogen rate up to 160 kg ha^{-1}. Green fodder yield revealed a significant and consistent increase with increase in seed rate up to 80 kg ha^{-1}, whereas dry fodder yield recorded significant increase only up to 60 kg seed rate ha^{-1} (Table 2). Increase in fodder yield at higher seed rate may be due to more number of plants per unit area, taller plant and higher leaf area index per unit area. Similar findings have been reported by Ayub *et al*. (1999), Malik *et al*. (2007) and Osman *et al*. (2010). Further, it is evident from the results that the dry fodder yield recorded at 60 and 80 kg seed rate ha^{-1} were statistically similar but green fodder yield recorded at 80 kg seed rate ha^{-1} was significantly higher than in 60 kg seed rate ha^{-1} (Table 2), indicating that at higher plant density the fodder contains more moisture which got reduced during sun drying, thereby caused statistically similar dry fodder yield at seed rate of 80 kg and 60 kg ha^{-1}. The interaction effect between nitrogen levels and seed rates for green and dry fodder yields was significant during both the years of study. Green fodder yield at all the nitrogen levels tested increased significantly up to 80 kg seed rate ha^{-1} and at all levels of seed rate the green fodder yield increased significantly up to 120 kg N ha^{-1} during both the years. Significantly higher green fodder yields of 448.2 and 456.1 q ha^{-1} in 2009 and 2010, respectively, was recorded in treatment combination N_{120} x S_{80}. However, during 2009 the green fodder yield recorded in N_{120} x S_{80} was at par with N_{120} x S_{60} (Table 2). Dry fodder yield at fixed levels of N varied significantly between S_{60} and S_{40} and S_{80} and S_{40} and at fixed seed rates, the dry fodder yield varied significantly between N_{90} and N_{60} and N_{120} and N_{60}. Significantly highest fodder yields of 119.59 and 120.95 q ha^{-1} in 2009 and 2010, respectively, were recorded in treatment combination N_{120} x S_{80} which was at par with N_{120} x $S_{60,}$ N_{90} x S_{80} and N_{90} x S_{60} (Table 2).

Conclusions: The nitrogen level of 120 kg ha^{-1} and seed rate of 80 kg ha^{-1} gave better green fodder yield in maize and N at 120 kg ha^{-1} and seed rate sown at 60 kg ha^{-1} responded better in terms of dry fodder yield. In present study it was found that seeds sown @ 80 kg ha^{-1} recorded significantly reduced stem diameter values than recorded at 60 kg seed rate ha^{-1} which is good from digestibility and palatability point of view as livestock show disliking for thick stalk portion and prefer tender stem and leafy portion to eat. Apart from this, higher leaf area index values were recorded with seed rate of 80 kg ha^{-1}. Hence N @ 120 kg ha^{-1} and seed rate of 80 kg ha^{-1} may be recommended to provide maximum green, succulent and palatable fodder per unit area under temperate conditions of Kashmir.

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