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Effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (Zea mays L.) grown in rabi season

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Abstract: *A field experiment was conducted at Agronomy research Farm of C.S. University of Agriculture and Technology, Kanpur (U.P), during rabi season in 2010-11 and 2011-12 to evaluate the effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (Zea mays L.) grown in rabi season. The experiment was laid out in split plot design with three replications. Where involved eighteen treatment combinations. The main plots were allotted by maize hybrid (DHM-117) and composite (Madhuri) along with three spacing, 45cm x 20 cm, 60cm x 20 cm and 60cm x 25 cm. And sub plots, were tested three fertility levels viz, F_1- NPK and Zn of (120:60:40 and 15 kgha^{-1}) F_2 -NPK and Zn of (160:80:60 and 20 kgha^{-1}) and F_3 - NPK and Zn of (180:100:80 and 25 kgha^{-1}). The result revealed that the maximum growth parameters likes, plant height (cm), no of leaves/plant, dry weight (gm^{-2}) and LAI were obtained with maize hybrid (DHM-117) followed by composite (Madhuri). The spacing of 60cm x 20cm significantly increased the cob length (16.87 and 17.09 cm), cob girth (11.23 and 11.80 cm), cob weight (205.90 and 205.90 g), grains weight/cob (170.52 and 173.94 g), grain yield (6.62 and 6.75 t/ha), protein content (8.78 and 8.87 %) and protein yield (58.20 and 60.00 kg/ha) than the spacing of 60cm x 25 cm and 45cm x 20cm, respectively. Significantly grain and protein yield was obtained under NPK and Zn of (180:100:80 and 25 kgha^{-1}) as compare to NPK and Zn of (120:60:40 and 15 kgha^{-1}) and NPK and Zn of (160:80:60 and 20 kgha^{-1}). The interaction effect wet been variety x spacing was found significant ($P<0.05$) on protein yield in both the years of experiments.*

Key words: *Maize, spacing, NPK and Zn, protein content and protein yield.*

Maize (Zea mays L.) is one of the most important cereals crop in the world agricultural economy both as food for man and feed for animals including poultry. It is also known as “queen of cereals’’ because of very high yield potential. Green cobs are roasted and consumed by people with great interest. The grains of special variety called the ‘pop corn’ are characterized by a hard corneous interior structure converted into the ‘popped’ form, which is the favourite food for children in urban areas. Several food dishes including chapaties are prepared out of maize flours and grains. It is also a good food for poultry, piggery and other animals.

Separate winter maize programmed was started in 1975 realizing its potential in almost all non-temperate areas of country, winter maize on an average yields 1.5 times higher than rainy season maize. The researches indicated that the winter maize gave favourable responds to better crop management (Singh et al. 2000).

The number of plants per unit area is influenced by the distance between row and distance between plants in row. Select an optimum plant spacing that allows for ease of the field operations, such a fertilizer application and weeding, minimizes competition among plants for light, water and nutrients and creates a favourable micro-climate in the canopy that reduced the risk for pests and diseases. Narrow row width of about 50 to 70 cm is recommended to ensure that sunlight falls on the plants and not on bare soil. This reduced weed competition and loss of soil moisture from evaporation.

The winter maize crop is highly responsive to fertilizer specially nitrogen and zinc. Thus, by increasing the levels of these nutrients, the yield was increased significantly. The nitrogen is an essential constituent of proteins, nucleotides, phosphotides, enzymes, hormones, vitamins etc. and thus, utilizing basic constituent of life. Nitrogen is an integral part of chlorophyll, which is primary absorber of light energy needed for photosynthesis. Nitrogen also governs the utilization of potassium, phosphorus and elements.

I. Materials And Methods

The experimental crops were raised on field No. 7/2 and 5/2 in both the years at Students Instructional farm, C.S. Azad University of Agriculture and Technology, Kanpur. This farm is situated on the University campus at 26^{0}29’35 North latitude and 80^{0}18’25 east longitude elevation from mean sea level is 125.9 meter. Experimental field was well leveled and had assured irrigation facility by tube well. It is situated in alluvial belt of middle Gangatic plain in central part of Uttar Pradesh having class second of land capability. This zone has semi-arid climatic conditions having alluvial fertile soil. The normal rainfall of the area is about 890 mm per annum. Most of the rains are received from June to the end of the September. The winter months are cooler with occasional frost during last week of December to mid January. The temperature in May and June may go up to 44-47 ^{0}C or beyond this while the minimum temperature during winter goes to 2-3 ^{0}C. Mean relative humidity (7 a.m.) remains nearly constant at about 80-90% from July to end of March and afterwards slowly declines to about 40-50% by the end of April and remains 80% up to June. The treatments comprised two maize varieties hybrid (DHM-117) and composite (Madhuri) and three plant geometry 45 cm x 20 cm, 60 cm x 20 cm and 60 cm x 25 cm in main plots and three fertility levels viz., N, P_2O_5, K_2O and $ZnSO_4$ of (180: 100: 80 and 25 kg/ha), N, P_2O_5, K_2O and $ZnSO_4$ of (150:80: 60 and 20 kg/ha) and N, P_2O_5, K_2O and $ZnSO_4$ of (120: 60: 40 and 15 kg/ha) in sub plots. The treatments were evaluated in split plot design with three replications. The experiments were sown on 30th October in 2010 and on 16th October in 2011. The application of nitrogen and phosphorus was done in the form of urea and DAP, Potash and zinc were supplied in the form of muriate of potash and zinc sulphate as per the treatments. The crop was harvested at full ripe stage on 24th April and 10th April, in 2011 and 2012, respectively. Soil of the experimental field was sandy loam in texture having organic carbon (0.43 and 0.45%), available N (179.60 and 180.50 kg/ha), available P_2O_5 (19.10 and 19.20 kg/ha), available K (128.0 and 128.25 kg/ha) and available Zn (0.74 and 0.76 ppm) and soil pH (7.50 and 7.60) in respective the years of experimentation.

II. Calculation

Leaf area per plant

Leaf area was measured by the following formula

Leaf area = Leaf length × Leaf breath × factor.

The length of the fully opened leaf lamina was measured from the base to the tip. Leaf breath was taken at the widest point of the leaf lamina. The product of the leaf length and breadth was multiplied by the factor 0.75 (Saxena and Singh, 1965) and the sum of leaf area of all the leaves was expressed as cm^2 per plant.

Leaf area index (LAI)

LAI was calculated as per the procedure given by Sestak et al. (1971)

$$LAI = \frac{A}{P}$$

Where,

A: Leaf area per plant (cm^2)

P: Land area covered by individual plant (cm^2)

Protein content

Total N content was determined from the various varieties of maize (hybrid and composite) of each treatment by modified Micro-Kjeldahl method (Piper, 1966). The protein percentage from the maize was calculated by the following formula.

Per cent protein = N % × 6.25 (Factor)

III. Results And Discussion

Plant height (cm)

Maximum plant height (224.50 and 228.99 cm) was recorded with hybrid maize (DHM-117) as compared to (181.66 and 185.29 cm) composite maize (madhuri) at silking stage.The differential growth with respect to plant height observed among the varieties may be attributed to differences in genetic characteristics of the individual varieties, including rapid growth rates, tallness or shortness of species. This is similar to the findings of Pal and Bhatnagar (2012) Spacing 60cm x 20 cm had taller plant than spacing 45cm x 20 cm and 60cm x 25cm possibly because of increased competition for space, sunlight and available nutrients, Laskari (2011). Application of successive dose of N, P_2O_5, K_2O and $ZnSO_4$ of (180, 100, 80 and 25 kg/ha) F_3 treatment was obtained taller plant followed by application N, P_2O_5, K_2O and $ZnSO_4$ of (150, 80, 60 and 20 kg/ha) F_2 and N, P_2O_5, K_2O and $ZnSO_4$ of (120, 60, 40 and 15 kg/ha) F_1, respectively in 2010-11 and 2011-12. Availability of higher nutrition to the growing plant might have resulted in better growth of plant resulted in terms of higher plant height. Similar results of increased plant height with higher doses of nitrogen, phosphorus, and potash and zinc fertilizers were reported by Mahesh et al. (2010).

No of leaves/plant

The significantly maximum number of leaves were obtained with hybrid (DHM-117) followed by composite (Madhuri) at silking stage. This might be due to the differences observed in the number of leaves of maize may be attributed to differences in growth characters which are being influenced by genetic make-up of the plants. This is similar to the findings of Gollar et al. (1996). Maize plant sown at spacing 60x20 cm (17.09-17.44) had higher number of leaves than spacing 45cm x 20 cm (16.25 and 16.56) and 60cm x 25 cm (15.81-16.16) because of increased growth rate in search for space, sunlight and other environmental resources, Chougule (2003) The maximum number of leaves and probably higher chlorophyll content under the higher nitrogen levels of N, P_2O_5, K_2O and $ZnSO_4$ of (180, 100, 80 and 25 kg/ha) F_3 followed by N, P_2O_5, K_2O and $ZnSO_4$ of (150, 80, 60 and 20 kg/ha) F_2 and N, P_2O_5, K_2O and $ZnSO_4$ of (120, 60, 40 and 15 kg/ha) presented in Table-1.

Table 1 plant height (cm), no of leaves/ plant, leaf area index and dry weight (gm^2) of maize plant as influenced by variety, spacing and fertility levels.

Treatment	Plant height (cm) at silking stage		No of leaves/ plant at silking stage		Dry weight (gm^{-2}) at silking stage		LAI at silking stage	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Variety								
Composite (Madhuri)	181.66	185.29	14.70	14.98	261.64	266.84	4.96	5.05
Hybrid (DHM-117)	224.50	228.99	18.07	18.46	323.29	329.76	5.99	6.10
SEm±	3.08	3.08	0.23	0.22	4.14	4.22	0.05	0.05
CD (P=0.05)	9.71	9.73	0.72	0.71	13.06	13.30	0.16	0.17
Spacing								
45cm x 20 cm	201.11	205.12	16.25	16.56	289.61	295.50	5.43	5.53
60cm x 20 cm	211.60	215.84	17.09	17.44	305.06	311.10	5.68	5.79
60cm x 25 cm	196.54	200.47	15.81	16.16	282.74	288.30	5.31	5.41
SEm±	3.77	3.78	0.28	0.27	5.07	5.16	0.06	0.06
CD (P=0.05)	11.90	11.92	0.88	0.87	15.99	16.28	0.20	0.21
Fertility levels								
NPK and Zn (120:60:40 and 15 kg/ha)	183.61	187.28	14.78	15.10	264.40	269.69	5.00	5.10
NPK and Zn (160:80:60 and 20 kg/ha)	206.36	210.48	16.66	17.00	297.20	303.14	5.55	5.66
NPK and Zn (180:100:80 and 25kg/ha)	219.28	223.66	17.71	18.06	315.81	322.07	5.86	5.97
SEm±	2.36	2.46	0.20	0.20	4.39	4.49	0.06	0.06
CD (P=0.05)	6.91	7.20	0.59	0.59	12.84	13.13	0.19	0.19

Dry weight (gm^{-2})

Enhance dry weight (323.29- 329.76 gm^{-2}) was observed with hybrid maize (DHM-117) followed by composite maize (madhuri) show the Table 1. The dry matter might be increased due to increase the LAI, no of leaves/ plant and height of plant. Similar results were reported by Iptas and Acar et al. (2006). Spacing 60x20 cm was recorded higher dry weight (305.06 and 311.10 gm^{-2}) followed by plant geometry 60x25 cm (282.74 and 288.30 gm^{-2}) and 45x20 cm (289.61 and 295.41 gm^{-2}). This was at par with plant geometry 45x20 cm at silking stage in 2010-11 and 2011-12. This might be due to maximum plant height, number of leaves, and leaf area index. Similar results were discussed by Thavaprakaash et al. (2005) Increase the fertility levels increased the dry weight. The dry weight (315.18 and 322.07) was noticed with the application of N, 180 kg, P_2O_5, 100 kg, K_2O, 80 kg and $ZnSo_4$, 25 kgha^{-1}. There was significantly higher over N, 120 kg, P_2O_5, 60 kg, K_2O, 40 kg and $ZnSo_4$, 15 kgha^{-1} and N, 150 kg, P_2O_5, 80 kg, K_2O, 60 kg and $ZnSo_4$, 20 kgha^{-1}. This might be due to available nutrients present in soil results plant uptake more NPK and Zn from the soil.

Leaf area index (LAI)

Maize hybrid (DHM-117) contents more LAI (5.99 and 6.10) than (4.96 and 5.05) maize composite (Madhuri).The differences observed in leaf area index of the varieties of maize sown could be attributed to the differences in leaf arrangement, photosynthetic activities of leaves, differences in chlorophyll content and activity of photosynthetic enzymes. This is similar to the findings of Kalloli, Gollar et al. (1996). All the growth stages of maize crop, spacing 60x20 cm recorded significantly higher leaf area index compared to spacing 45x20 cm and 60x25 cm at silking stage. This might be due to larger leaf area index possibly because of reduction in competition for space, sunlight and nutrients within the wider spaced plants, Thavaprakaash et al. (2005). Leaf area index of maize plant was significantly influenced at harvest stage. This might be probably due to higher chlorophyll content under the higher fertility levels N, P_2O_5, K_2O and $ZnSO_4$ of (180, 100, 80 and 25 kg/ha) which made the crop photosynthetically more active Reddi and Reddy (2007). Spacing 60 cm x 20 cm obtained higher dry weight followed by spacing 60cm x 25 cm and 45cm x 20 cm (Table-1). This might be due to maximum plant height, number of leaves, and leaf area index. These results are in agreement with the findings of Reddi and Reddy (2007)

Yield attributes

Yield attributes viz; cob length, cob girth, cob weight /plant, grains weight/cob significantly influents by spacing and fertility levels present in Table 2. The maximum yield attributes were obtained with hybrid maize (DHM-117) compared to composite maize (Madhuri). This might be due to hybrid maize varieties have yield advantage over composite variety because they possess such special qualities as high yield, disease resistance, and early maturity, uniformity in flowering and ear placement. Better performance of yield attributes in 60 cm x 20cm spacing was mainly due to better availability of resources such as sunshine, movement of air and availability of nutrients than the wide spacing (60cm x 25cm) and narrow spacing 45cm x 20cm. Similar findings were reported by Lashkari et al. (2011). The cob length (16.9 and 17.2 cm), number of rows/ cob (14.1 and 14.4), number of grains/row (40.7 and 41.3), cob weight (207.6 and 217.9 g) and grains weight/cob weight (176.5 and 179.8 g) were significantly maximum when enhance dose of fertilizers viz., N, P_2O_5, K_2O and $ZnSO_4$ 180, 100, 80 and 25 kg/ha (F_3). This might be due to adequate supply of nutrients results turn improve the overall growth of the plants. These results agreement with these are reported by Parasuraman et al. (2008).

Table 2 Length of cob, girth of cob, weight of cob and weight of grains/cob of maize plant as influenced by variety, spacing and fertility levels.

Treatment	Cob length (cm)		Cob girth (cm)		Cob weight (g)		Grains weight/cob (g)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Variety								
Composite (Madhuri)	14.80	15.02	8.87	9.35	176.59	180.00	146.25	149.25
Hybrid (DHM-117)	18.01	18.37	12.60	13.12	214.15	222.93	180.75	184.21
SEm±	0.17	0.17	0.14	0.15	2.73	2.23	2.31	2.35
CD (P=0.05)	0.56	0.56	0.45	0.47	8.62	7.02	7.28	7.40
Spacing								
45cm x 20 cm	16.37	16.69	10.68	11.23	195.51	199.83	161.91	165.25
60cm x 20 cm	16.87	17.09	11.23	11.80	205.90	209.93	170.52	173.94
60cm x 25 cm	15.98	16.30	10.29	10.82	185.30	194.63	158.07	161.01
SEm±	0.21	0.21	0.17	0.18	3.35	2.73	2.83	2.87
CD (P=0.05)	0.68	NS	0.55	0.58	10.56	8.60	8.92	9.07
Fertility levels								
NPK and Zn (120:60:40 and 15 kg/ha)	16.09	16.29	10.46	11.00	178.49	181.90	147.81	150.88
NPK and Zn (160:80:60 and 20 kg/ha)	16.22	16.54	10.77	11.31	200.63	204.56	166.16	169.48
NPK and Zn (180:100:80 and 25 kg/ha)	16.91	17.24	10.98	11.54	207.60	217.94	176.53	179.84
SEm±	0.20	0.20	0.13	0.13	3.01	2.81	2.46	2.48
CD (P=0.05)	0.60	0.59	0.38	0.40	8.81	8.22	7.19	7.26

Yield

Maximum grain yield (7.02 and 7.17 t/ha) and stover yield (12.66 and 12.85 t/ha) was observed with maize hybrid (DHM-117) compared to composite (Madhuri) in both the years of experiments. This might be due to genetic makeup of the plant, internally morphological characters and insect, disease resistance. Spacing 60 cm x 20 cm getting higher grain (6.62 and 6.75 t/ha) and stover yield (11.97 and 12.23 t/ha). This might be due to plant receive more sunlight by the canopy of plant and sufficient nutrient from the soil which results higher growth of plant and maximum yield attributes, Rao (2010). Application of N, P_2O_5, K_2O and $ZnSO_4$ (180, 100, 80 and 25 kg/ha, respectively) F_3, recorded significantly higher grain yield (6.86 and 7.00 t/ha) and stover yield (12.38 and 12.51 t/ha). The lower dose of fertilizes N, P_2O_5, K_2O and $ZnSO_4$ (120, 60, 40 and 15 kg/ha) F_1, recorded the lower grain and stover yield. This might be due to the fact that higher levels of NPK and Zn led to adequate supply of nutrients to the plant resulting in better growth which in turn led to better physiological process and movement of photosynthates to sink, Paramasivan et al. (2011).

Protein content (%) and yield

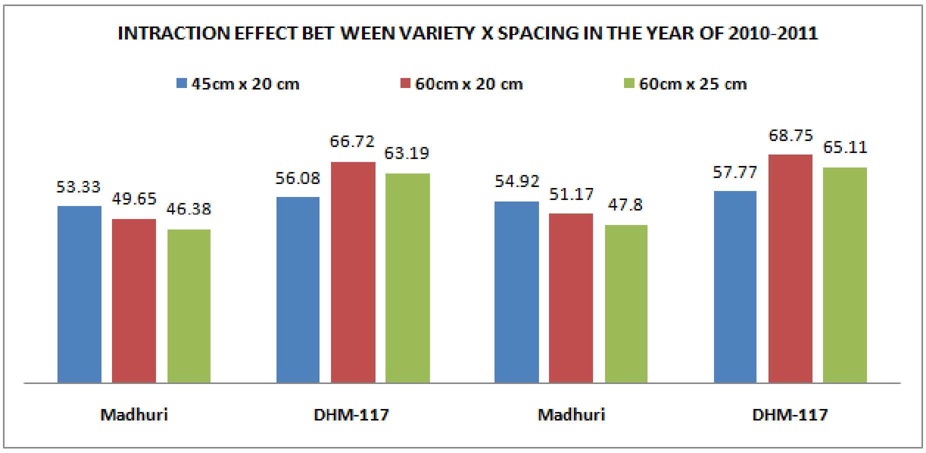
The protein content and yield was significantly affected by the variety, spacing and fertility levels in 2010-11and 2011-12 presented in Table 3. The maximum protein content (8.81 and 8.90 %) and yield (62.0 and 63.9 kg/ha) was observed with maize hybrid (DHM-117) followed by maize composite (8.75 and 8.84 %) (49.8 and 51.3 kg/ha) Madhuri. The variation in the quality parameters between the genotypes may be because of genetic behavior of the genotypes tested. This is similar to that obtained by Carrillo et al. (2005). Spacing 60cm x 25 cm recorded significantly maximum protein content (8.89 and 8.97 %). It was at par with spacing 60cm x 20 cm in 2010-11 and significantly higher over rest of the treatments in 2010-11 and 2011-12. Spacing 60x20cm was observed to produced maximum protein yield (58.2 and 60.0 kg/ha). It was significantly higher over rest of the treatments in 2010-11. But non-significant differences were found in 2011-12 for protein yield. This was attributed to the higher nitrogen content in maize plant under the spacing 60x20cm. Similar results were obtained by Kar et al. (2006).

Table 3 Grain yield (t/ha), Stover yield (t/ha), Protein content (%) and Protein yield (kg/ha) of maize plant as influenced by variety, spacing and fertility levels.

Treatment	Grain yield (t/ha)		Stover yield (t/ha)		Protein content (%)		Protein yield (kg/ha)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Variety								
Composite (Madhuri)	5.68	5.80	10.76	10.86	8.75	8.84	49.80	51.30
Hybrid (DHM-117)	7.02	7.17	12.66	12.85	8.81	8.90	62.00	63.90
SEm±	0.06	0.09	0.13	0.13	0.02	0.02	0.69	0.90
CD (P=0.05)	0.21	0.29	0.42	0.42	NS	NS	2.17	2.84
Spacing								
45cm x 20 cm	6.29	6.42	11.62	11.77	8.68	8.76	54.70	56.30
60cm x 20 cm	6.62	6.75	11.97	12.23	8.78	8.87	58.20	60.00
60cm x 25 cm	6.15	6.28	11.53	11.56	8.89	8.97	54.80	56.50
SEm±	0.08	0.11	0.16	0.16	0.03	0.03	0.84	1.10
CD (P=0.05)	0.25	0.36	0.52	0.52	0.09	0.11	2.66	3.47
Fertility levels								
NPK and Zn (120:60:40 and 15 kg/ha)	5.75	5.86	10.88	11.03	8.59	8.68	49.40	50.90
NPK and Zn (160:80:60 and 20 kg/ha)	6.46	6.59	11.86	12.03	8.76	8.85	56.61	58.30
NPK and Zn (180:100:80 and 25 kg/ha)	6.86	7.00	12.38	12.51	8.99	9.08	61.70	63.60
SEm±	0.07	0.08	0.13	0.15	0.03	0.03	0.77	0.75
CD (P=0.05)	0.23	0.23	0.40	0.44	0.10	0.09	2.25	2.20

The interaction effects were also found significant (Table 4) for protein yield (kg/ha) with respect to variety and spacing (VxS). Maize composite (Madhuri) along with spacing 45 cm x 20 cm recorded maximum protein yield (53.33 and 54.92 kg/ha). It was at par with plant geometry 60x20 cm and significantly higher over V_1S_3 treatment combination. In case of maize hybrid (DHM-117) along with spacing 60 cm x 20 cm maximum protein yield (66.72 and 68.75 kg/ha) was observed. This was also significantly higher over V_2S_1 treatment combination. This might be due to more uptake of nutrient specially nitrogen and zinc sulphate, the vital role played by the zinc in synthesis of protein and Indole Acitic Acid, Chlorophyll formation and carbohydrates metabolism and in auxin metabolism may be assigned for increased protein content and protein yield in maize grain. Similar results were reported by Lashkari et al. (2011)

Table 4: Protein yield (kg/ha) of maize under V×S interaction (2010 and 2011)



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