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YIELD COMPONENT, YIELD AND NUTRIENT CONTENT OF WINTER POPCORN (*Zea mays everta* Sturt.) INFLUENCED BY PLANTING TIME, FERTILITY LEVEL AND POPULATION DENSITY UNDER LATE SOWN CONDITION

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Abstract: *The field experiment were conducted in 2009-10 and 2010-11 late winter season to determine the effect of planting time (15th December, 30th December and 15th January), fertility level (100: 50: 50, 150: 65: 65 and 200: 85: 85 kg of N: P_2O_5: K_2O ha^{-1}) and population density (60,000, 80,000 and 100,000 plants ha^{-1}) on yield component (No. of grain cob^{-1}, 100-grain weight, grain weight $plant^{-1}$), yield and nutrient concentration (N:P:K content in soil and plant) of winter popcorn at the Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.). The experiment was computed in a split plot design in three replications. The results showed that planting time had significant effect on number of kernel cob^{-1}, grain wt. cob^{-1}, grain yield and straw yield and N, P and K content. So, that highest grain yield was obtained with 32.03 qtl and 35.49 qtl ha^{-1} on December, 15 during consecutive both the years. However, the density of 80,000 plants ha^{-1} gave significantly highest value of No. of kernel cob^{-1}, grain yield (27.4 qtl ha^{-1} in 2009-10 and 32.06 qtl ha^{-1} in 2010-11). The fertilizer application significantly affected on studied traits. Application of 200:85:85 kg of N:P:K ha^{-1} produced grain yield of 31.00 qtl and 32.88 qtl ha^{-1}, respectively during both the years.*
Keywords*: Pop corn, planting time, fertility level, grain yield, N, P and K content.*

Introduction: Introduction of high productivity maize crop is worth exploring for enhancing the food production. The ability of the maize crop to grow in different seasons and high productivity of *Rabi*/winter and *Spring* maize give it added advantages for inclusion in the cropping system as demand for more food grows. As the winter maize are gaining popularity among farmers and multinationals because of lower photo respiration losses due to lower night temperatures as well as larger leaf surface for effective photosynthetic activities.

Pop corn (*Zea mays var. everta*) is perhaps the most primitive of the surviving race of corn. It is a most popular foodstuff in peri-urban areas in big cities of all over the world and nutritious snack food. This corn type is characterized by a very hard, corneous endosperm containing only a small portion of soft starch. Majority of the world's popcorn production is in the United States. Considering the above facts and factor influencing yield, Sustainable maize production depends on the correct application of production inputs sustaining both the environment and agriculture. In an attempt to increase productivity, plant spacing has to be optimized and an important factor determining grain yield of corn, because grain yield per unit area is the product of grain yield per plant and number of plants per unit area. At low plant densities, grain yield is limited by an inadequate number of plants per unit area, whereas at too high densities, yield declines mostly because of an increase in the number of aborted kernels and/or barren plants. An optimum plant density should be maintained to efficiently exploit the growth factors, such as nutrients, sunlight and soil water to ensure productivity and economic sustainability of yields [1].

Grain yield is a function of several factors and processes that affect the productivity of winter popcorn however; the fertilizer management is one of the most important factors that affect the growth and yield of popcorn. Popcorn is an exhaustive crop which requires all types of macro and micro nutrients in order to get better growth and exploit yield potential. Among the various nutrients, nitrogen is the principal nutrients which should be applied@ 150 kg N ha^{-1} in order to have better harvest. The efficiency of nitrogen utilization is better in *Rabi* than in *Kharif* season, primarily because of better water management and lower leaching losses. With better fertilizer response, it should be possible to substantially reduce the cost of production of every tonne of maize produced in *Rabi* season.

Materials and Methods

The field experiment was carried out during two consecutive winter seasons of 2009-10 and 2010-11 at the Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) on sandy clay loam soil with the pH 7.6, organic carbon 0.35 %, available nitrogen 183 kg ha^{-1}, available phosphorus 21.02 kg ha^{-1} and available potassium 228 kg ha^{-1} in the beginning of present investigation. The experiment was laid out in split plot design and replicated three times. Nine combinations of two variables consisting of three planting time viz. D_1(15th December), D_2(30th December) and D_3(15th January), and three plant population density viz. P_1(60,000), P_2(80,000) and P_3(100,000) plants ha^{-1} were assigned to the main plots. Whereas the three fertility levels viz. F_1(100-50-50), F_2(150- 65- 65) and F_3(200- 85- 85) kg of N-P_2O_5-K_2O ha^{-1} were allotted to the sub plot. The following techniques were used during experimentation (Table-1 & 2).

Table 1: Yield parameters of winter popcorn as influenced by planting time, plant population density and fertility levels under late sown condition

Treatment	Grain Wt. COB^{-1} (gm)		Kernal Row COB^{-1}		No. of Kernal COB^{-1}		Grain Yield (Qtl. ha^{-1})		Stover Yield (Qtl. ha^{-1})	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Planting Time										
15th December	57.3	73.99	13.10	13.78	356.71	389.04	32.03	35.49	47.68	53.14
30th December	49.1	69.13	13.01	13.41	342.22	356.64	27.32	29.82	46.80	48.42
15th January	30.5	67.26	12.59	13.41	265.79	353.44	21.64	26.03	43.38	47.50
S.EM±	0.8	1.53	0.15	0.27	7.87	10.25	0.83	0.46	0.96	0.82
C.D.(P= 0.05)	2.5	4.60	NS	NS	23.60	30.74	2.48	1.39	2.87	2.47
Population Density (Plant ha^{-1})										
60,000 Plant ha^{-1}	48.6	76.14	12.85	13.41	303.41	357.05	25.03	28.49	43.22	48.29
80,000 Plant ha^{-1}	45.1	67.20	13.01	13.78	331.95	389.00	28.15	32.06	46.68	49.23
100,000 Plant ha^{-}	43.1	67.04	12.85	13.41	329.37	353.07	27.79	30.79	47.95	51.53
S.EM±	0.8	1.53	0.15	0.27	7.87	10.25	0.83	0.46	0.96	0.82
C.D.(P= 0.05)	2.5	4.60	NS	NS	23.60	30.74	2.48	1.39	2.87	2.47
Fertility level (N, P_2O_5 and K_2O ha^{-1})										
100: 50: 50	55.27	67.85	12.52	13.19	301.74	313.09	23.65	27.73	42.19	45.46
150: 65: 65	56.9	69.10	12.90	13.26	308.43	372.76	26.32	30.73	45.38	50.20
200: 85: 85	61.42	73.44	13.29	14.15	354.55	413.28	31.00	32.88	50.28	53.39
S.EM±	1.375	1.65	0.14	0.25	11.56	13.63	0.73	0.45	0.71	0.64
C.D.(P= 0.05)	3.91	4.73	0.39	0.72	33.17	39.09	2.09	1.30	2.05	1.83

Table 2: Nutrient content in Grain and Stover of winter popcorn as influenced by planting time, plant population density and fertility levels under late sown condition.

Treatment	N content (%)				P content (%)				K content (%)			
	Grain		Stover		Grain		Stover		Grain		Stover	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Planting Time												
15th Dec.	1.60	1.61	0.93	0.96	0.219	0.229	0.149	0.151	0.328	0.331	1.472	1.556
30th Dec.	1.46	1.49	0.88	0.85	0.205	0.209	0.134	0.140	0.325	0.320	1.450	1.473
15th Jan.	1.03	1.05	0.63	0.71	0.185	0.186	0.133	0.137	0.310	0.307	1.367	1.367
S.EM±	0.02	0.03	0.02	0.02	0.002	0.004	0.004	0.004	0.004	0.006	0.018	0.025
C.D.(P= 0.05)	0.06	0.10	0.06	0.07	0.007	0.012	0.012	0.011	0.013	0.019	0.054	0.075
Population Density (Plant ha^{-1})												
60,000 Plant ha^{-1}	1.26	1.29	0.68	0.72	0.182	0.188	0.132	0.136	0.313	0.313	1.393	1.405
80,000 Plant ha^{-1}	1.41	1.44	0.89	0.91	0.217	0.221	0.147	0.150	0.329	0.330	1.463	1.496
100,000 Plant ha^{-1}	1.41	1.43	0.87	0.89	0.210	0.215	0.138	0.143	0.322	0.315	1.432	1.495
S.EM±	0.02	0.03	0.02	0.02	0.002	0.004	0.004	0.004	0.004	0.006	0.018	0.025
C.D.(P= 0.05)	0.06	0.10	0.06	0.07	0.007	0.012	0.012	0.011	0.013	0.019	0.054	0.075
Fertility level (N, P_2O_5 and K_2O ha^{-1})												
100: 50: 50	1.32	1.34	0.72	0.71	0.184	0.188	0.120	0.128	0.311	0.310	1.386	1.420
150: 65: 65	1.36	1.37	0.79	0.81	0.200	0.204	0.142	0.141	0.314	0.319	1.408	1.434
200: 85: 85	1.41	1.45	0.92	1.00	0.224	0.232	0.155	0.160	0.339	0.329	1.494	1.541
S.EM±	0.02	0.03	0.02	0.04	0.001	0.005	0.004	0.003	0.004	0.006	0.028	0.036
C.D.(P= 0.05)	0.06	0.08	0.06	0.11	0.004	0.015	0.013	0.010	0.012	0.018	0.081	0.104

Seed and Sowing: Healthy and clean seed of required quantity was used for sowing. The Seed was sown at 4-5 cm depth with three inter and intra row spacing 60 cm and 27.8 cm, 20.8 and 16.6 cm, respectively. Sowing was done in furrow open by narrow spade (Kudal) on 15^{th} December, 30^{th} December and 15^{th} January in 2009 and 2010 with referred spacing to maintain a population of 60,000, 80,000 and 100,000 plant ha^{-1} during experimentation.

Fertilizer Application: As per treatment fertilizers were placed in furrows made by narrow spade (Kudali), at a depth of 5 cm and apart from the seed rows by side dressing. The urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) were used as sources for nutrient elements. Fertilizer for all the three levels was applied in three equal splits at sowing, knee high and tasseling stage in their respective treatments. However, a common dose of phosphorus and potassium were applied as basal dressing at the time of three date of sowing.

Intercultural and After Care: Thinning was done 20 days after sowing to maintain proper plant stand of respective plants ha^{-1}. Intercultural operations such as weeding, hoeing etc. were done as and when required to control weeds, conserve soil moisture and facilitates good aeration. Earthing up was taken up between 50 days after sowing to prevent lodging.

The spraying of Endosulphan 35 EC was done to control the attack of stem borer in the crop. Bonfire and crackers were also used to prevent damage by stray animals and birds.

Chemical Analysis of Plant: The plant and grain samples at harvest were used for chemical analysis. The plants and grain were dried in an oven and grinded thoroughly in a Willy mill to pass through a 30 mesh sieve. These were preserved in sealed and leveled containers for chemical analysis.

Preparation of plant extract and seed samples were digested in the acid mixture (HNO_3: $HCIO_2$: H_2SO_4 in 10: 4: 1 ratio) nitrogen was determined by modified Kjeldahl method [2]. Digested materials were obtained by hydrogen peroxide method [3]. The phosphorus was estimated by calorimetric method [2]. Potassium was estimated by flame photometer [2]. The grain and stover samples were digested in the acid mixture (HNO_3: $HCIO_2$ in 10: 4 ratios). The extract so obtained was used for sulphur estimation.

Results and Discussion

Effect of Treatments on Yield Attributes and Yield: The maximum number of kernel cob^{-1}, grain wt. cob^{-1}, grain yield and straw yield was tended to record with planting at 15^{th} December followed by 30^{th} December and 15^{th} January during both the year. The result corroborated with the finding [4]. This might be due to the longer time available for the early sown crop to utilize available growth resources (light, nutrient, moisture etc) to produce and partition more assimilates to the various sinks for better vegetative growth, leading to the production of higher yield and yield components than the late sown crops in both years. While, seed weight decreased due to the change in showing dates. This confirmed with the finding [5]. The differences in seed weight might be due to the environmental conditions mostly observed during the plant life cycles. Reported that ear length reduced by higher plant densities [6]. This may be due to the effect of interplant competition for light and soil water and nutrients [7]. The percent increase in straw yield of 2010-2011 was recorded 11.45% higher due to sowing at 15^{th} December as compared to 2009-2010 with same period of planting. However, the number of plants at harvest stover yield increased with increasing plant density whereas the number of kernel rows cob^{-1} and number of kernel row^{-1} decreased with non-significant differences. However, significantly highest value of number of kernel cob^{-1} and grain yield (27.4 q ha^{-1} in 2009- 2010 and 32.06 q ha^{-1} in 2010-2011) recorded with implied to density of 80,000 plants ha^{-1}. This clearly indicated that plants at lower density fully exploited the natural resources efficiently, besides responding to externally applied inputs and expressed the same liberally compared to plant at highest plant density where the competition was stiff. Confirms these results [8], whether, statistically superior value for grain wt. cob^{-1} obtained with density of 60,000 plants ha^{-1} indicating a stress free environment [9]. Each increment of fertility levels from 100-50-50 kg of N-P_2O_5-K_2O ha^{-1} to 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} influenced the yield attributes markedly. The dose of fertility at 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} significantly improved all the yield attributes. The application of 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} recorded significantly more number of kernel row cob^{-1} and grain weight cob^{-1}over its immediate lower dose which recorded at par value for yield attributes viz. kernel row cob^{-1} (first year), grain weight cob^{-1}(during second year) and number of kernel row cob^{-1} (during first year) of the experimentation. These activities promote higher photosynthetic activities leading to the production of enough assimilate for subsequent translocation to various sink and hence the production of higher yield and yield component of popcorn. The grain yield was highest (31.00 qtl ha^{-1} in 2009- 2010 and 32.88 qtl ha^{-1} in 2010-2011) with 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} than yield received by rest of the treatments. The increasing fertility levels caused the increase of yield indices which, in turn, increased the grain yield. Increased corn yield with an increase in fertility level was also reported [10]. Similarly, stover yield was highest (50.28 q ha^{-1} in 2009- 2010 and 53.39 q ha^{-1} in 2010-2011) in 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} applied plot and it was significantly higher than those of the plots received than yield received 150-65-65 kg and 100-50-50 kg of N-P_2O_5-K_2O ha^{-1}.

Effect of Treatments on Nutrient Content: The significantly higher N, P and K content in grains and stover was recorded with planting at 15th December as compared to 30th December and 15th January in both the years. Relatively early planted popcorn (15th December) availed longer favourable environmental conditions which improved functional activity of root system and increased the availability of plant nutrients, and thus the crop had more nitrogen, phosphorus and potassium content in grain and stover. This was in conformity with the findings [11-12]. Whether differences for K content in grain and stover was at par with planting at 30th December by 15th December. The P content in stover did not showed statistical differences during second year of the present investigation. While, at medium plant density of 80,000 plants ha^{-1} significantly increased the N, P and K content in grain over 100,000 plants ha^{-1}, where similar result were showed with 80,000 plants ha^{-1} in the experimentation during both the years. Accordingly application of 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} recorded maximum N, P and K content and showed its significant superiority 100-50-50 kg of N-P_2O_5-K_2O ha^{-1} but the differences were statistically at par with 150-65-65 kg of N-P_2O_5-K_2O ha^{-1} for K content in grain in second year and N content during both the year of the experimentation. The increase in N, P and K content in grain and stover might be attributed due to greater availability of these nutrients and account of increased application to the crop plants which led to their higher absorption and accumulation in grain and stover. Similar, results have been found [13].

Conclusion: The plants sown on 15th December significantly produced higher yield components, yield of popcorn and their N, P, K content over those sown on 30th December and 15th January. While, the application of 80,000 plants ha^{-1} to popcorn crop, grown in late winter season significantly proved to be economically in realizing higher grain yield over 100,000 and 60,000 plants ha^{-1}. Further, among the fertility doses, application of 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} showed its significant superiority in respect of yield attributes, yield and N, P, K content over 100:50:50 kg and 150:65:65 kg N-P_2O_5-K_2O ha^{-1}. The sowing of popcorn under late winter season i.e. 15th December under 80,000 plants ha^{-1} with application of 200-85-85 kg of N-P_2O_5-K_2O ha^{-1} could be produced higher grain yield than extreme late winter condition.

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