

Original Research Article

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Effect of Nitrogen and Phosphorus Level on Dry Matter Yield at Different Growth Stages of Popcorn in South Saurashtra Region of Gujarat, India

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ABSTRACT

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A field experiment was conducted during *rabi* season of 2013-14 on calcareous soil under Saurashtra region. The experiment consisted of four levels of nitrogen (0, 90, 120, 150 Kg N ha⁻¹) and four levels of phosphorus (0, 45, 60, 75 Kg P₂O₅ ha⁻¹) making sixteen treatment combinations tested in factorial randomized block design with three replications. The results indicated that application of 150 Kg N ha⁻¹ and 75 Kg P₂O₅ ha⁻¹ significantly increased the dry matter at 30DAS, 60DAS and at harvest of different stages of plant parts of Popcorn. The overall results indicated that combined application of nitrogen shows the synergistic effect on growth attributes of popcorn and sustain the yield.

Introduction

In Indian agriculture, maize assumes a special significance on account of its utilization as food, feed and fodder besides several industrial uses. According to latest data (2012-13), it is being cultivated on 8.49 million hectares with 80% area during *kharif* season. Nowadays, the maize corn used for popcorn, is profitable for a lot of producers and traders. Maize production is 21.28 million tonnes, with an average productivity of 2.5 t ha⁻¹ (NIIR, 2013). The current maize is grown on 9.3 million hectares with production of 24.2 million tonnes and productivity of 2602 kg ha⁻¹ in the country (FAO STAT, 2014). Despite maize being predominantly rainfed crop its productivity is more than rice which is mainly

grown under assured irrigated/rainfed conditions. Maize contributes nearly 9% in the national food basket and more than 400 billion to the agricultural GDP at current prices. In Gujarat, the important districts growing maize are Dahod, Panchmahal, Vadodara, Sabarkantha, Kheda, Banaskantha, Bharuch, Anand and Dang.

The area under maize in the Saurashtra region is almost negligible. It is mainly cultivated in *kharif* season, and due to photo insensitive crop, it is also grown as *rabi* and summer crop. The maize is classified into seven principal groups on the basis of endosperm and floral bract or glume character *viz.*, pod corn, popcorn, flint corn, dent corn, soft corn,

sweet corn and waxy corn (<http://www.itis.gov>). Popcorn is very popular snack food in many parts of the world. The use of popcorn confectionaries and popcorn products especially in amusement parks, moving picture theaters etc greatly increased the demand for popcorn products and have made a profitable outlet for those who desire to grow popcorn on a commercial scale.

Nitrogen and phosphorus consumption has a strange effect on production of popcorn and expanding leaf area plants which receive the most nitrogen and phosphorus contain more leaf area index than wild plants. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of efficient utilization, particularly at 25 days after sowing and pre-tasseling (40 days after sowing) stages for higher productivity. Nitrogen and Phosphorus are the two most essential nutrients in popcorn. Others nutrients that are limiting in soil and require fertilization for popcorn are K, S, Zn, Fe, etc. To produce one tone of grain and dry matter, maize crop withdraws 8.0 kg of N, 2.5 kg of P₂O₅ and 18 kg of K₂O from the soil.

Materials and Methods

A field experiment was conducted during rabi season of 2013-14 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The soil was clayey texture and slightly alkaline in reaction with pH 8.0 and EC 0.27 dS m⁻¹.

The soil was medium in available nitrogen (260.34 kg ha⁻¹), medium in alkaline in reaction with pH 8.0 and EC 0.27 dS m⁻¹. The soil was medium in available nitrogen (260.34 kg ha⁻¹), medium in available phosphorus (42 kg ha⁻¹) and medium in available potash (238 kg ha⁻¹) and low in available sulphur about of (12 kg ha⁻¹). The crop was fertilized with

nitrogen and phosphorus as per treatment allotted to each plot. The nutrient levels were four levels of N (0, 90, 120, 150 Kg N ha⁻¹) and four levels of phosphorus (0, 45, 60, 75 Kg P₂O₅ ha⁻¹) and totally 16 different treatment combinations were laid out. The calculated quantity of entire dose of phosphorus and half dose of nitrogen were applied as basal application in the form of Urea and SSP at just before sowing in the furrows. Remaining half dose of nitrogen were top dressed in two splits as urea at 20 and 40 DAS, whereas sulphur supplied through SSP was equalized by cosavet ferti-WG (90% S). All other cultural and plant protection measures were followed as recommended.

The popcorn variety Amber was used for this study. This variety was released in 1981 by SVRC, suitable for kharif and rabi season growing under irrigated conditions. The seeds were dibbled at a spacing of 60 cm x 20 cm using a seed rate of 15 kg ha⁻¹ during the last week of November 2013. The data collected from experiment at different crop growth stages, yield, yield attributes, quality and chemical study were subjected to statistical analysis followed for Randomized Block Design in factorial nature as denoted by Panse and Sukhatme (1985).

Five plants per plot were selected randomly in the net plot are and tagged for observations at critical stages (30 DAS, 60 DAS and at harvest) for recording growth and yield parameters. Destructive sampling was followed to record dry weight at different stages.

The five randomly collected plants were dried at room temperature for two days and then oven dried at 65°C till a constant weight was obtained. The oven dry weight was recorded for estimating the dry matter yield in (g plant⁻¹).

Results and Discussion

Effect of nitrogen on dry matter yield at different growth stage

The dry weight of leaves, stem, root, grain and total plant was significantly influenced by the different levels of nitrogen (Table 1 and Fig. 1). The dry weight of leaves, stem, root and total plant was recorded significantly higher with 150 kg N ha⁻¹ (N₃) with values of 4.983, 16.565, 3.170 and 24.718 g plant⁻¹ respectively of popcorn at 30 DAS. The dry weight of leaves, stem, root and total plant was significantly influenced by the different levels of nitrogen. The dry weight of leaves, stem, root and total plant were recorded significantly higher with application of nitrogen @ 150 kg N ha⁻¹ (N₃) with values of 20.26, 26.61, 5.18, and 52.30 g plant⁻¹, respectively. It was also remained at par with application of 120 kg N ha⁻¹ (N₂) for dry weight of leaves (18.84 g plant⁻¹) and stem (25.45g plant⁻¹). The dry weight of leaves, stem, root and total plant (Fig. 1) at harvest were significantly affected by different nitrogen level on popcorn which was recorded higher with application of nitrogen @ 150 kg N ha⁻¹ (N₃) in value of 26.29, 30.86, 9.43, 62.33 and 130.51 g plant⁻¹ respectively at 60 DAS (Table 1). It was also remained at par with 120 kg N ha⁻¹ (N₂) for dry weight of leaves (24.53 g plant⁻¹) only.

The dry matter accumulation rate by virtue of increased photosynthetic efficiency can be explained by the fact that the supply of nitrogen enhances the production of leaves, stem small roots and root hairs, which in turn facilitated the high absorbing capacity per unit dry weight. N uptake by maize fodder in response to nitrogen application was in close bearing with the response of total plant dry matter to N nutrient as had recently been reported by (Hussaini *et al.*, 2001). Increased dry matter production with increased fertilizer

application was due to role of nitrogen in determining the efficiency of sunshine by the increased biomass and any inadequacy of nitrogen reduces the sunshine use efficiency or ability to photosynthesize as reported by (Wadsworth, 2002). Thus greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased dry weight of vegetative parts of plants *i.e.*, leaves, stem, root and grain. Initially, leaves rather than the number is increases but the number of leaves are subsequently increased by sustained leaf production over a longer period. Total dry matter production of sweet corn increased with increasing levels of nitrogen at all growth stages of crop observed by Kumar (2007). Such result clarified that N is essential for cell division and elongation as well as the root growth and dry matter yield of maize plants, Marschner (1995). The application of nitrogen was found to increase the leaves dry weight of maize which may be due to selective and adequate nitrogen uptake in plant tissue. The leaves dry weight was significantly obtained from application of higher dose of nitrogen 180 kg ha⁻¹ (Hokmalipour and Darbandi, 2011). Singh (2001) reported that in baby corn, increasing nitrogen levels recorded significant increase in dry matter production in maize up to 150 kg N ha⁻¹ both in kharif and summer seasons. Total dry matter production was found significantly higher by maximum application of nitrogen (125 kg ha⁻¹) in popcorn, (Kanannavar, 2013). The total dry matter production per plant differed significantly due to nitrogen levels. Every increase in nitrogen level from 75 to 225 kg ha⁻¹ increased the dry matter production from 266 to 323 g plant⁻¹ (Setty, 1981) in maize. Similar result was reported by Choudhary and Singh (2006), Hokmalipour *et al.*, (2010), Babak *et al.*, (2012) and Chabi *et al.*, (2008), Verma and Singh (2014), Kumar (2009) in popcorn.

Effect of phosphorus on dry matter yield at different growth stage

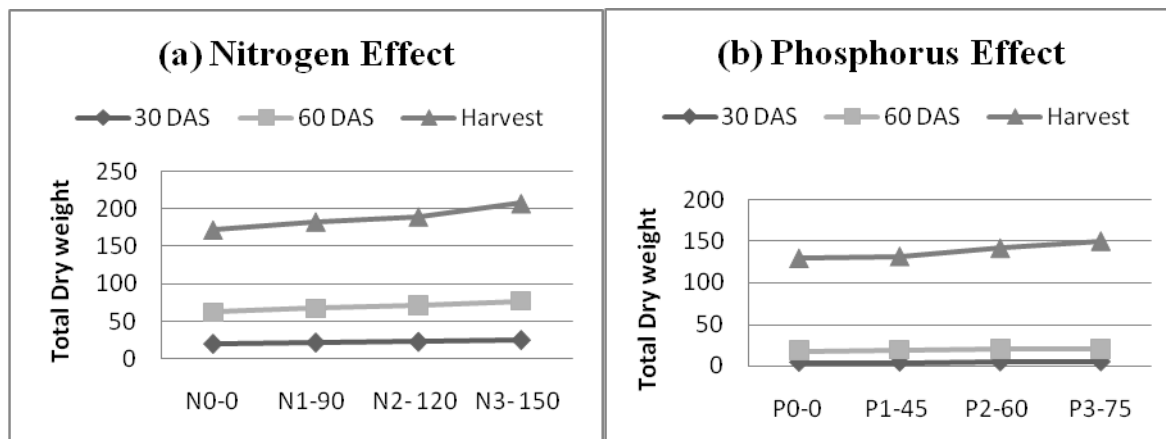
The data furnished in table 2 and figure 4.2.5 indicated that phosphorus applications at various levels significantly influenced the dry weight of leaves (20.24 g plant⁻¹), stem (26.35 g plant⁻¹), root (5.01 g plant⁻¹) and total plant (51.61 g plant⁻¹) which were recorded higher under applications of phosphorus @ 75 kg ha⁻¹ (P₃). Which were statistically at par with 60 P₂O₅ kg ha⁻¹(P₂) in leaves (18.91 g plant⁻¹) at 60 DAS. The interaction effect of nitrogen and phosphorus was found non-significant in terms of dry weight of leaves, stem, root and total plant of popcorn at 60 DAS. The data furnished in (Table 1 and Fig. 1b) indicated that phosphorus applications at various levels significantly influenced the dry weight of leaves (4.616 g plant⁻¹), stem (15.465 g plant⁻¹), root (3.038 g plant⁻¹) and total plant (23.118 g

plant⁻¹) which were recorded higher under applications of phosphorus @ 75 kg P₂O₅ ha⁻¹ (P₃). It was found statistically at par with 60 kg P₂O₅ ha⁻¹ (P₂) for leaves (4.501 g plant⁻¹), root (2.795 g plant⁻¹) and total plant (22.499 g plant⁻¹), while 45 kg P₂O₅ ha⁻¹ (P₁) and 60 kg P ha⁻¹ (P₂) for stem with value of 14.939 and 15.203 g plant⁻¹ at 30 DAS. The interaction effect of nitrogen and phosphorus was found non-significant in terms of dry weight of leaves, stem, root and total plant of popcorn at 30 DAS. Increased dry matter production with increased fertilizer application was due to role of NPK in determining the use efficiency of sunshine by the increased biomass and any inadequacy of nitrogen reduces the sunshine use efficiency or ability to photosynthesis as reported by Wadsworth (2002), Chabi *et al.*, (2008), Verma and Singh (2014), Kumar (2009) in popcorn.

Table.1 Effect of nitrogen and phosphorus on dry matter at 30 DAS, 60 DAS and at harvest of popcorn

Treatments	30 DAS			60 DAS			AT Harvest			
	Leaves	Stem	Root	Leaves	Stem	Root	Leaves	Stem	Root	Grain
Nitrogen (kg N ha⁻¹)										
N ₀ -0	3.86	13.42	2.45	16.80	21.45	3.92	21.49	25.71	7.14	55.49
N ₁ -90	4.05	14.56	2.81	18.18	23.14	4.43	24.07	26.61	8.09	56.85
N ₂ - 120	4.42	15.07	2.83	18.84	25.45	4.51	24.54	27.72	8.36	57.84
N ₃ - 150	4.98	16.56	3.17	20.26	26.61	5.18	26.30	30.86	9.44	62.33
S.Em.±	0.11	0.29	0.08	0.53	0.65	0.13	0.67	0.74	0.23	1.22
C.D. at 5%	0.32	0.84	0.24	1.53	1.87	0.38	1.93	2.14	0.67	3.54
Phosphorus (kg P₂O₅ ha⁻¹)										
P ₀ -0	4.00	14.02	2.68	17.22	21.45	4.00	22.63	24.37	7.13	55.30
P ₁ -45	4.20	14.93	2.73	17.70	23.44	4.44	23.06	25.05	7.96	56.15
P ₂ -60	4.50	15.20	2.79	18.92	24.00	4.58	24.77	29.58	8.63	58.58
P ₃ -75	4.61	15.46	3.03	20.24	26.35	5.02	25.94	31.90	9.30	62.48
S.Em.±	0.11	0.29	0.08	0.53	0.65	0.13	0.67	0.74	0.23	1.22
C.D. at 5%	0.32	0.84	0.24	1.53	1.87	0.38	1.93	2.14	0.67	3.54
NxP Interaction										
S.Em.±	0.22	0.58	0.17	1.06	1.29	0.26	1.33	1.48	0.47	2.45
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	9.11	6.77	10.44	9.88	9.28	10.04	9.60	9.24	9.80	7.30

Fig.1 Effect of nitrogen and phosphorous on total dry weight of leaves, stem, root and grain (g plant^{-1}) at different growth stages



The application of phosphorus @ 75 kg ha^{-1} (P_3) gave significantly higher dry weight of leaves ($25.94 \text{ g plant}^{-1}$), stem ($31.90 \text{ g plant}^{-1}$), root ($9.30 \text{ g plant}^{-1}$), grain ($62.48 \text{ g plant}^{-1}$) and total plant ($129.62 \text{ g plant}^{-1}$). It was remained at par with dry matter yield of leaves ($24.77 \text{ g plant}^{-1}$) and root ($8.63 \text{ g plant}^{-1}$) after harvest of popcorn. The interaction effect of nitrogen and phosphorus did not produced significant effect on dry weight of leaves, stem, root, grain and total plant of popcorn at harvest. Increased dry matter production with increased fertilizer application was due to role of P in determining the efficiency of sunshine by the increased biomass and any inadequacy of nitrogen reduces the sunshine use efficiency or ability to photosynthesized as reported by Wadsworth (2002). Thus greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased dry weight of vegetative parts of plants *i.e.*, leaves, stem root and grain. Initially, leaf rather than the number is increases but the numbers of leaves are subsequently increased by sustained leaf production over a longer period. However, it was noticed that the dry mass of the leaves sample with the highest phosphorus dose of $75 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ was found significantly higher than the other lower level, similar result seen

by El-Hamdi and Woodard (1995) and Lu and Miller (1993), where the increase of phosphorus dose, increased the percentage of content of nutrients, the dry matter accumulation significantly increased by maximum application of phosphorus. Banerjee *et al.*, (2006), Arya and Singh (2011) in maize, The present findings are within the close vicinity of those reported with phosphorus by Padmaja *et al.*, (1999), Raja (2001), Sahoo and Mahapatra (2004), Pal (2013), Babak *et al.*, (2012), Mehta (2002), Chabi *et al.*, (2008), Gokmen *et al.*, (2001), Kumar (2009), Kanannavar (2013), Prathyusha and Hemalatha (2013) in popcorn.

However, the results seems quite logical to conclude that significantly the higher dry matter yield of leaf, root, stem, grain and total plant at 30DAS, 60DAS and at harvest were obtained from rabi popcorn (cv. Amber) by fertilizing the crop with nitrogen application @ 150 kg N ha^{-1} (N_3) and $75 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ (P_3) in medium black calcareous soils of Saurashtra region of Gujarat.

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