

# GROWTH AND AVAILABLE NUTRIENT IN WINTER MAIZE (*ZEA MAYS L.*) WITH VEGETABLE INTERCROPS IN EASTERN UTTAR PRADESH

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## ABSTRACT

A field experiment was conducted during the winter season in the years 2010-2011 at agriculture research farm the Banaras Hindu University, Varanasi. To find out the production potential and nutrient status of winter maize (*Zea mays L.*) intercropped with various vegetable like radish (*Raphanus sativus*) spinach (*Spinacia oleracea L.*) and carrot (*Daucus carota*). Values of plant height (209.99cm), no of active leaves (10.90) and plant dry matter (171.02 g plant<sup>-1</sup>) at 120 DAS and cob height (95.49 cm), grain yield of maize (69.99 q ha<sup>-1</sup>) significantly greater in sole crop than the intercropping systems, and days to 50% tasseling (110.50), days to 50% silking (117.0) and barren on plants plot<sup>1</sup> (1.70), maize equivalent yield (282.46 q ha<sup>-1</sup>) was significantly higher in intercrops than the sole maize crop. Result also revealed that association of carrot with maize crop improved availability of residual nitrogen, phosphorous and potassium.

## INTRODUCTION

The continuous increasing pressure on cultivable land for food and commercial crops, because of the human population load as well as unlimited use under industrial and civil sector, now it is difficult to put additional area in agriculture sector. This phenomenon is a serious threat to food grain production in the country, and that too at the time when more and more quality production is required at greater level. The intercropping in diversified form is a good crop cultivation practice recognized in India. The concept and principals of intercropping lead to improve the productivity per unit area and time, and also make possible to judicious utilization of resources and inputs at cost effective level.

To stabilize crop production and to provide insurance mechanism against aberrant weather situation characterizing rain fed agriculture, Inter cropping could be a viable agronomic means of risk minimizing farmers profit and subsistence-oriented, energy-efficient and sustainable venture Faroda *et al.*, (2007). Since maize (*Zea mays L.*) is a widely spaced crop, inter-row space could profitable be utilized for vegetable in the intercrops. Intercropping is an age-old practice it has attracted world-wide attention owing to yield advantages Willey, (1979). If the crops selected are compatible and grown with improved production technology. The fertilizer requirement of intercropping system may also vary from sole cropping owing to inclusion of crop of dissimilar nature. The role of fertilization in winter maize and maize based cropping systems is well established Sinha *et al.*, (1999).

Maize is a more versatile crop for growing in intercrops, because it is wide space crop and providing higher income to the farmers short duration variation of pulses, most vegetable, and oilseed crop can be successfully intercropped in maize. The yield of pure maize under inter cropping is in no way lower but the inter-crop is a bonus Singh *et al.*, (2012). Maize cultivation in winter season is now gaining more popularity due to high yield potential, minimum losses due to biotic factors and greater responses to applied nutrients. Little information is available on the response of maize and intercrop to fertilizer. Hence, the main objective in the present study efforts were made to optimize the production of maize and intercrops, and to find out the effect of intercrops on the available nutrients (kg ha<sup>-1</sup>).

## MATERIALS AND METHODS

An investigation was carried out during the winter (*Rabi*) season in the years 2010-2011 at the agriculture research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil is alluvial with sandy loam texture, deep, The pH range is neutral to slightly alkaline in reaction (pH 7.6), (Glass electrode pH meter, Jackson 1973). Well drained and moderately fertile being medium in organic carbon (0.52%), (Jackson 1967). Low in available nitrogen (145.0 kg ha<sup>-1</sup>), (Alkaline permanganate, subbiah and asija 1973). Medium in phosphorus (15.5 kg ha<sup>-1</sup>), (0.5 N NaHCO<sub>3</sub> extractable, Olsen *et al*, 1924). And available potassium (162.5 kg ha<sup>-1</sup>), (Ammonium acetate extractable flame photometer,

Jackson 1973). There were 11 treatments combination comprising 5 sole crop, viz maize (*Zea mays* L.), radish (*Raphanus sativus*), spinach (*Spinacia oleracea* L.) and carrot (*Daucus carota*) T<sub>1</sub> - Pure (sole maize) normal, T<sub>2</sub> - Pure (sole maize) paired, T<sub>3</sub> - Sole-Radish, T<sub>4</sub> - Sole-Spanish, T<sub>5</sub> - Sole-carrot, and 6 intercropping combinations T<sub>6</sub> - Maize normal + Radish, T<sub>7</sub> - Maize paired + Radish, T<sub>8</sub> - Maize normal + Spanish, T<sub>9</sub> - Maize paired + Spanish, T<sub>10</sub> - Maize normal + carrot, T<sub>11</sub> - Maize paired + carrot, tried in randomized block design with 4 replications. The varieties employed were, Hybrid maize (Bio-seed)-9544, radish-Hill queen (Golden vigo), Spinach- local (Desi), Carrot-E.N (Gulshan seeds). The experimental crops were sown late on 14 December 2010 and harvested at different dates, i.e. maize on 16 May 2011, the radish and carrot uprooted on 13 February 2011 and 09 April 2011 respectively, and 2 cuttings of spinach taken from first fortnight of February to end of February during the experimentation year. Maize was sown at two different spacing 75 cm space in between rows and paired row planting 100-50 cm space in between rows and 20 cm plant to plant spacing in both of planting method. Among the intercrops (radish, spinach and carrot) row to row spacing was 25 cm. recommended package of practices was followed to raise the healthy crop. Maize was fertilized with 150 kg N, 90 kg P<sub>2</sub>O<sub>5</sub> and 90 kg K<sub>2</sub>O, while 50 kg N, 100 kg P<sub>2</sub>O<sub>5</sub> and 50 kg K<sub>2</sub>O in radish, 120 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 60 kg K<sub>2</sub>O in carrot and 35 kg N, 50 kg P<sub>2</sub>O<sub>5</sub> and 50 kg K<sub>2</sub>O ha<sup>-1</sup> in spinach. In intercropping, the crops received the fertilizers on the basis of proportionate area under each crop. Full recommended doses of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O along with one-third N to maize, 50% N to radish, spinach and carrot was applied as basal to all the crops in sole as well as intercropping system. Remaining two-third N to winter maize was top-dressed in 2 equal splits at knee high and tasseling stage. Rest 50% N was applied after first irrigation to all the intercrops. Fertilizer requirement of all the crops was met through urea, single super phosphate (SSP) and muriate of potash (MOP). Maize-equivalent yield was calculated on the basis of minimum support prices of component crops for the main produce and prevailing market prices for the inputs. Growth parameters, viz. plant height (cm), no of active leaves, plant dry matter (g), barren on plants plot<sup>-1</sup> (9.35 m<sup>2</sup>) and cob height (cm) were recorded at harvest stage. For the computation of maize grain equivalents and economics per 100 kg market price of Rs. 800, Rs. 80, Rs. 500, Rs. 500 and Rs. 1000 for maize, stover, radish, spinach and carrot, respectively were used. Soil samples after harvest of crops were collected for analysing the organic carbon and available nitrogen, phosphorus and potassium contents as per the standard analytical method. The Initial Available nutrients in 145.0, 15.5 and 162.5 (NPK kg ha<sup>-1</sup>) found in the experimental field.

## RESULTS AND DISCUSSION

### Growth and yield parameters

The growth attributes of *Rabi* maize plant i.e. plant height, functional leaves per plant, dry matter accumulation per plant and cob height (cm) got affected significantly when planted with different inter-crops (radish, spinach and carrot) at

successive growth stages under. The harmful effect of inter crop on maize was probably due to not liking association with the root on one hand and the less availability of nutrients and environmental resources viz. solar radiation, light, moisture and space to grow freely for the maize plant on the hand. The recessive growth attributes of maize under intercropping systems may also be due to antagonistic effect between different plant species through the secretion of allelochemicals by root exudates of radish and maize plant. The reduction in various growth parameters viz. plant height and dry matter accumulation of winter maize under intercropping associations has been also reported by Jha *et al.* (2002).

The intercropping of carrot as root vegetable with winter maize established its superiority in growth parameters over the radish and spinach, and it was also comparable to sole maize systems (normal and paired). Consequently, some growth parameters of maize when intercropped with carrot viz. dry matter accumulation at physiological maturity (120 DAS) functional leaves per plant and height at (120 DAS) growth stages had comparable differences with sole maize, these results are in agreement with the result of Barik and Tiwari (1996). Probably the carrot intercrop was less aggressive as compared to other vegetables and because of this fact the carrot exerted less competition for nutrient, light, moisture and space. Consequently, maize plants did grow comfortably under maize + carrot association and performed better pertaining to growth attributes. These circumstances hereby made available some extra nutrients to the maize crop. Thus additional advantage of resources might have resulted in over all development of maize crop in terms of growth attributes. The developmental characters like day to 50% tasseling, day to 50% silking as well as number of barren plants are ultimate reflection of different growth attributes. Since, growth parameters were affected due the effect of treatments, consequently the developmental characters (day to 50% tasseling, day to 50% silking and number of barren plants), also varied accordingly in the study. These results are in agreement with the result of Kumar *et al.* (2006).

It was observed in general that planting pattern also affected the growth attributes (plant height, functional leaves per plant, dry matter accumulation per plant) of maize, and normal planting (75 x 20 cm) brought out higher values of growth characters over paired sole maize (100: 50). The normal planting of maize provided equal opportunity to all the plants for nutrient, moisture and light. Whereas, paired planting although maintained the required plant population but at the same time also increased the row-row to competition and by virtue of such competition, the growth attributes were also varied significantly. Similar effect was also experienced under intercropping system irrespective of intercrops.

Maize grain yield was significantly influenced by different intercrops in combination Association of radish, spinach and carrot in normal maize planting significantly decreased the grain yield of maize by 24.0 %, 2.90 % and 13.99 % also paired row planting decrease the grain yield of maize by 19.15 %, 3.90 % and 9.68 % respectively, compared with the sole cropping of maize this may be due to decrease in yield attributing characters, viz. cob length (cm), cob girth No of kernel rows cob-l, No of kernel row-l, No of grain cob-l, grain

**Table 1: Effect of vegetable intercropping on growth attributes of winter maize**

Treatment	Plant height (cm)	No of active leaves	Plant dry matter (g plant <sup>-1</sup> )	Days to 50% tasseling	Days to 50% silking	Barren on plants plot <sup>-1</sup>	Cob height (cm)
T <sub>1</sub> : Maize (N) sole	209.99	10.90	170.10	108.50	113.75	0.56	84.49
T <sub>2</sub> : Maize (P) sole	205.83	10.63	171.02	106.00	113.00	1.13	95.49
T <sub>6</sub> : Maize (N) + radish	176.24	8.47	150.92	110.50	117.00	0.56	66.91
T <sub>7</sub> : Maize (P) + radish	187.49	8.62	130.77	109.00	115.00	1.70	78.91
T <sub>8</sub> : Maize (N) + spinach	189.16	9.20	148.05	106.25	112.25	1.13	94.41
T <sub>9</sub> : Maize (P) + spinach	203.33	9.20	153.70	108.25	114.00	1.13	89.58
T <sub>10</sub> : Maize (N) + carrot	199.99	9.72	169.32	107.75	113.00	1.70	93.49
T <sub>11</sub> : Maize (P) + carrot	199.16	9.95	117.97	107.75	113.50	0.56	91.57
SEm ±	3.72	1.11	8.015	0.801	0.461	-	3.148
CD (p = 0.05)	10.95	3.29	23.573	2.358	1.356	-	9.259

N - normal row, p - paired row

**Table 2: Effect of vegetable intercropping on grain yield, equivalent yield and economics of winter maize**

Treatment	Grain yield (q/ha)	Maize equivalent yield (q/ha)
	Main crop	Inter crop
T1: Maize(N) sole	67.37	-
T6: Maize(N) + radish	51.20	168.53
T8: Maize(N) + spinach	65.41	73.45
T10:Maize(N) + carrot	57.94	168.53
T2: Maize (P) sole	69.99	-
T7: Maize (P) + radish	56.58	172.71
T9: Maize (P) + spinach	67.26	78.36
T11: Maize (P) + carrot	63.21	175.40
T3: Radish (sole)	275.79	-
T4: Spinach (sole)	124.35	-
T5: Carrot (sole)	297.70	-

N - normal row, P = paired row

**Table 3: Effect of vegetable intercropping on available NPK and nutrient balance of soil in winter maize**

Treatments	Available nutrients (kg ha <sup>-1</sup> )								
	Nitrogen			Phosphorus			Potassium		
	Initial	Final	Gain/loss	Initial	Final	Gain/loss	Initial	Final	Gain/loss
T <sub>1</sub> : Maize(N) sole	145.0	138.11	-6.89	15.5	26.16	+10.66	162.5	206.57	+44.07
T <sub>2</sub> : Maize (P) sole	145.0	143.41	-1.59	15.5	24.85	+9.35	162.5	169.64	+7.14
T <sub>6</sub> :Maize (N) + radish	145.0	196.79	+51.79	15.5	33.24	+17.74	162.5	258.19	+95.69
T <sub>7</sub> : Maize (P) + radish	145.0	176.11	+31.11	15.5	30.29	+14.79	162.5	223.47	+60.97
T <sub>8</sub> : Maize (N) + spinach	145.0	136.82	-8.18	15.5	21.62	+6.12	162.5	100.22	-62.28
T <sub>9</sub> : Maize (P) + spinach	145.0	124.51	-20.49	15.5	21.32	+5.82	162.5	109.94	-52.56
T <sub>10</sub> : Maize (N) + carrot	145.0	175.60	+30.60	15.5	28.71	+13.21	162.5	195.57	+33.07
T <sub>11</sub> : Maize (P) + carrot	145.0	154.97	+9.97	15.5	26.55	+11.05	162.5	177.08	+14.58
CD (p = 0.05)	NS	39.76	-	NS	5.10	-	NS	60.99	-

N - normal row, P - paired row

wt cob-l (g), Cob yield plot-l (kg), and 1000 grain weight. Paired row planting of maize (100:50 cm) registered significantly higher maize yield than the normal planting (75 x 20 cm) Inter crops performed better under paired planting system which may be due to higher area, nutrient & sunlight available into crops. Among inter-cropping systems. Patra B.C *et al* (1990). Reported an increase in grain yield of maize by 2.32 to 7.5 per cent of maize when it was intercropped with grain legumes over sole cropping. Intercropping maize with peas at 2:2 row ratio appeared an efficient and economically viable system, giving the highest maize grain yield, maize equivalent yield. Similar results were also obtained by different worker at different places. Under sole winter maize treatment maize equivalent yield decreased significantly than its equivalent yield under maize based inter cropping association viz. maize + carrot, maize + radish and maize + spinach.

All the intercropping systems showed superiority over sole cropping of maize. Maximum maize equivalent yield (282.46

qha-1) was recorded under maize (paired) + carrot followed by maize(paired) + radish (164.25qha-1) and minimum in maize (paired) + spinach (116.21 qha-1) intercropping system. Higher maize equivalent yield under intercropping pattern of maize + carrot and maize + radish and maize + spinach might be due to the better utilization of resources and balanced competition between component crops. Secondary the better market prices of inter crops contributed to higher maize equivalent yield. These results are in conformity with the findings of Singh and Kumar (2002). Maize + radish was superior than the other intercropping systems in terms of total maize equivalent yield (247.9 qha-1), Intercropping with carrot, turnip and potato reduced the maize cob yield by 34.9, 31.4 and 27.8% respectively, compared to sole maize. Kumar *et al.* (2006) found that alternate row of maize and spinach was the most productive (maize equivalent yield of 9.72 t ha-1).

## Nutrient balance

Owing to introduction of vegetable with maize, the balance sheet on available nutrients indicated an increase in the availability of residual nitrogen, whereas maize associated with radish had left higher amount of residual nitrogen (+ 51.79 kg ha<sup>-1</sup>) than other cropping system. The lower uptake of nitrogen by the maize crop in maize radish association thereby resulted in more availability of residual nitrogen in the soil. That of maize associated with radish had also left higher amount of residual phosphorus (+ 17.74 kg ha<sup>-1</sup>) and potassium (+ 95.69 kg ha<sup>-1</sup>) Tripathy (1993) reported similar results. However, available soil phosphorus and potassium recorded loss due to greater total uptake of phosphorus and potassium by maize and legume association. Chowdhury and Rasario (1992) also observed similar findings.

Effect of intercropping system on available nutrient in soil

Intercropping of radish and carrot with maize increased the available soil N, P and K content in both normal and paired row planting than the sole crop and the maize with spinach exhibited lowest available nutrient in soil than the sole crop. The utilization of nutrient elements under intercropping system must be greater as compared sole system and because of this reason the status of available nutrient varied according to cropping system followed during experimentation. The results so obtained in the present study fully agree with the findings of Kumar *et al.* (2006). Thus, it can be concluded that intercropping of radish and carrot with maize can be suggested as a productive, remunerative and biologically sustainable intercropping system under winter season.

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