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Effect of Vegetable Intercrops and Planting Pattern of Maize on Growth, Yield and Economics of Winter Maize (*Zea mays* L.) in Eastern Uttar Pradesh

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Abstract A field experiment was conducted during the winter season in the years 2010-2011 to find out the effect of winter maize (*Zea mays* L.) intercropped with various vegetables like radish (*Raphanus sativus* L.) spinach (*Spinacia oleracea* L.) and carrot (*Daucus carota*). Values of plant height (10.50 cm) and (27.45cm), no. of active leaves (4.00) and (8.15) and plant dry matter (0.13 g plant^{-1}) and (1.45 g plant^{-1}) and leaf area index (0.57) and (1.75) and chlorophyll content (SPAR value), (41.38) and (48.40) and crop growth rate (4.33 mg day^{-1} plant^{-1}) and (48.33 mgday-1 plant^{-1}) at 30 and 120 DS and grain yield of maize (69.99 q ha^{-1}) were significantly greater in sole crop than the intercropping systems, and maize equivalent yield 9282.46 q ha^{-1}) and benefit : cost ratio (3.86) were significantly higher in intercrops than the sole maize crop.

Keywords Maize, Radish, Spinach, Carrot, Growth attributes.

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Introduction

In some parts of India, maize is successfully grown in winter with much higher yield as compared to conventional rainy season crop. To stabilize crop production and to provide insurance mechanism against aberrant weather situation characterizing rainfed agriculture, intercropping could be a viable agronomic means of risk minimizing farmers profit and subsistence-oriented, energy-efficient and sustainable venture (1). 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-old practice it has attracted world-wide attention owing to yield advantages (2). In case of winter sown maize, the growth of the crop is normal during first 30-40 days, while from December where temperature goes down, the rate of growth slows down rapidly till January. During this period when the growth almost ceases, there, is a scope of Taking intercrops which may enhance the total return. Similarly, with introduction of intercrops, the light interception and utilization capacity differ as compared to sole crop of maize Therefore, crop geometry plays vital role in augmenting yielding capacity of sole as well as intercrops. With these factors under consideration, a field trail was planned with different intercrops (3). Hence, in the present study efforts were made to optimize the production of maize and intercrops.

Materials and Methods

An investigation was carried out during the winter (rabi) season of 2010-1011 at the agriculture research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil is alluvial with sandy loam texture, deep, The *p*H range is neutral to slightly alkaline in reaction (pH 7.6), well drained and moderately fertile beingmedium in organic carbon (0.52%), low in available nitrogen (145.0 kg ha^{-1}), medium in phosphorus (15.5 kg ha^{-1}) and available potassium (162.5 kg ha^{-1}). 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_1 - Pure (sole maize) normal, T_2 - Pure (solemaize) paired, T_3 -Sole-Radish, T_4 - Sole-Spanish, T_5 - Sole-carrot, and intercropping combinations, T_6 - Maize normal + Radish, T_7 - Maize paired + Radish, T_8 - Maize normal + Spanish, T_9 - Maize paired + Spanish, T_{10} - Maize normal + carrot, T^{11} - Mize paired + carrot, tried in randomized block design with 4 replications. Varieties used in the experiment, hybrid maize (Bio-seed)-9544, radish-Hill queen (Golden vigro), Spinach-local (Desi), Carrot-EN 9Gulshan 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 9 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_2O_5 and 90 kg K_2O, while 50 kg N, 100 kg P_2O_5 and 50 kg K_2O in radish, 120 kg N, 60 kg P_2O_5 and 60 kg K_2O in carrot and 35 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} in spinach. In intercropping, the crops received the fertilizers on the basis of proportionate area under each crop. Full recommended doses of P_2O_5 and K_2O 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 and economics of production were calculated on the basis of minimum support prices of component crops forthe 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 $plot^{-1}$ (9.35 m^2) 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^{-1}) found in the experimental field. Leaf area of the sample plants was measured by multiplying the length and breadth of the leaves and then multiplying this value by a correction factor of 0.75 the correction factor was obtained by taking the actural leaf area of 175 randomly selected leaves by the automatic leaf area meter, and comparing it with area of same leaves obtained by multiplying the length and breath of the leaves. The leaf area index was then calculated by dividing the total leaf area of the plant by land area. The crop growth rate (CGR) was calculated by standard method (4). A nd Chlorophyll content was calculated with the help of SPAD value.

Results and Discussion

Effect of growth parameters

It is well established fact that maize plants are highly sensitive to low temperature, when it is grown during winter season, the initial establishment of maize plants be affected due to low temperature as the same occurred in the present study. Since the experimental crop was sown late on 14 December 2010, the temperature for seedling emergence and its growth was sub optimum At the same time the intercrops introduced in the experiment are primarily grown during winter season, thus intercrops exerted more competi-

Table 1. Effect of vegetable intercropping on growth attributes of winter maize. N = normal row, p = Paired row.

Treatments	Plant height (cm)		No of active leaves		Plant dry matter (g)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1 : maize (N) sole	10.50	27.45	4.00	8.15	0.12	1.27
T_2 : Maize (p) sole	10.22	26.87	3.75	7.62	0.13	1.45
T_6 : Maize (N) + Radish	9.70	24.37	4.00	5.62	0.12	0.65
T_7 : Maize (p) + Radish	9.90	26.37	3.75	6.80	0.11	0.90
T_8 : Maize (N) + Spinach	8.95	25.24	3.50	7.97	0.10	1.30
T_9 : Maize (p) + Spinach	8.22	23.66	3.75	7.55	0.11	1.12
T_{10} : Maize (N) + Carrot	9.55	26.10	3.75	7.70	0.11	1.27
T_{11} : Maize (p) + Carrot	9.77	25.49	3.75	7.22	0.11	0.85
SEm ±	0.69	1.92	0.57	0.54	0.015	0.190
CD (P =0.05)	2.03	5.67	1.68	1.60	0.046	0.558

tion for light, nutrient and moisture to main crop (maize). Hence, poor plant establishment of maize during initial growth stages spontaneously experienced more competition exerted by intercrops and resulted in poor plant stand which was more pronounced in case of radish intercrop during the study.

The growth attributes of *rabi* maize plant i.e. plant height, functional leaves per plant, dry matter accumulation per plant, leaf area index, chlorophyll content (SPAD) value), and crop growth rate at 30 and 60 DAS 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 reported earlier (5). The intercropping of carrot as root vegetable with winter maize established its spperiority 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 functional leaves per plant and height of maize had comparable differences with sole maize at 30, 60, DAS. These results are in agreement with the result earlier (6).

It was observed in general that planting pattern also affected the growth attributes (plant heigh, functional leaves per plant, dry matter accumulation per plant, leaf area index (LAI) of maize, normal planting (75 × 20 cm) brought out higher values of growth characters over paired sole maize (100:50). But chlorophyll content (SPAD value) and crop growth rate (mg/day/plant) days after sowing of maize, paired sole maize (100:50) brought out higher values over normal planting (75×20 cm). 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. Probably the carrot intercrop was less aggressive as compared to other vegetables and because of the fact the carrot exerted less competition for nutrient, light, moisture and space. Consequently, maize plants did grow comfortavly 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.

Leaf area index and crop growth rate

In revealed that LAI at earlier stage (30 DAS) there was no any significant difference but latter stage (60

Table 2. Effect of vegetable based intercropping on LAI, CGR, Chlorophyll content, grain yield, equivalent yield and economics of winter maize. N = normal row, p=Paired row.

Treatments	Leaf area index (LAI)		Chlorophyll Content (SPAD value)		Crop growth rate (mgday^{-1} plant^{-1}) days after sowing		Maize grain yield (q ha^{-1})	Maize equivalent yield (q ha^{-1})	Benefit : Cost ratio
	30 DAS	60 DAS	30 DAS	60 DAS	0-30 DAS	30-60 DAS			
T_1 : Maize (N) sole	0.57	1.75	40.33	47.03	4.00	42.33	67.37	67.37	1.37
T_2 : Maize (p) sole	0.57	1.75	41.38	48.40	4.33	48.33	69.99	69.99	1.48
T_6 : Maize (N) + Radish	0.56	1.68	35.86	43.96	4.00	21.66	51.20	156.46	2.24
T_7 : Maize (p) + Radish	0.57	1.68	36.17	44.09	3.66	30.00	56.58	164.25	2.41
T_8 : Maize (N) + Spinach	0.56	1.69	35.17	40.07	3.33	43.33	65.41	111.26	1.11
T_9 : Maize (p) + Spinach	0.56	1.69	35.48	40.13	3.66	37.33	67.26	116.21	1.19
T_{10} : Maize (N) + Carrot	0.56	1.67	36.21	45.21	3.66	42.33	57.94	268.56	3.62
T11: Maize (p) + Carrot	0.56	1.67	36.57	45.89	3.66	28.33	63.21	282.46	3.86
SEm ±	0.00	0.00	0.13	0.07	0.13	0.39	3.796	8.175	-
CD (p = 0.05)	NS	0.01	0.37	0.21	0.37	1.15	11.165	24.042	-

DAS) it was maximum insole maize crop than the intercrops because there was better utilization of available resopurces might have increased the functional leaves and in turn enhanced the LAI. and among the intercrops at 60 DAS, LAI was maximum found in maize + spinach intercrops (1.69) and minimum in maize + carrot (1.67) due to exhaustive nature of the crop. And among cropping pattern paired row sowing and normal sowing of maize there was no any difference at 30 and 60 DAS.

It was found that higher growth rate in sole maize than the intercrops and among the sole crop or cropping pattern paired row sowing had higher CGR as compared to normal sowing maize crop at 30 and 60 DAS and among the intercrops CGR was maximum found in maize + spinach intercrops (43.33) and minimum in maize + radish (21.66) at 60 DAS due to exhauative nature of the crop. Higher plant height and LAI joined together produced higher dry matter production and hence higher CGR. Similar result are also reported earlier (7).

Yield of maize and 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 sttributing characters, viz.cob length (cm), cob girth, no of kernel rows cob^{-1}. no of kernel row^{-1}, no of grain cob^{-1}, grain wt cob^{-1} (g), cob yield plot^{-1} (kg), and 1000 grain weight. Paired row planting of maize (100 : 50 cm) registered significantly higher maize yield than the normal planting (75×20 cm)Inter crops performed better under paired planting system which may be due to higher area, nutrient and sunlight available into crops. Among inter-cropping systems Patra et al. (8), reported an increase in grain yield of maize by 2.32 to 7.5% 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 and production efficiency. Mustard and wheat were not compatible with maize (9). Simalar 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 q ha^{-1}) was recorded under maize (paired) + carrot followed by maize (paired) + radish (164.25 q ha^{-1}) and minimum in maize (paired) + spinach (116.21 q ha^{-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 earlier findings (10). Maize + radish was superior than the other intercropping systems in terms of total maize equivalent yield (247.9 qha^{-1}), and maize stover yield (199.3 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.

Economics of the system

Inter cropping of carrot with winter maize registered higher B:C (3.86) followed by maize + radish (2.41) and minimum in maize + spinach (1.19) among intercropping. Which always better than the sole systems of maize. The results so obtained, are fully support from the previous work (9).

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