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Effect of Row Ratios and Nitrogen Levels on Growth and Growth Attributes of Popcorn Maize (*Zea mays Everta* L.) and Rajmash (*Phaseolus vulgaris* L.) Under Intercropping System

H. L. SHIRSATH[1*], R. SINGH[2] AND I. B. CHAVAN[3]

1 & 3Dept. of Agronomy, College of Agriculture, Wadgaon Gupta (Viladghat), Ahemadnagar, MS.
2Dept. of Agronomy, Allahabad Agricultural Institute-Deemed University, Allahabad UP
[*]email : hlshirsath@gmail.com

ABSTRACT

A field experiment was conducted during winter (rabi) season 2008-09 at experimental farm, Department of Agronomy, Allahabad Agricultural Institute, Allahabad, Uttar Pradesh, India. The experiment was carried out in Randomized Block Design (RBD) consisted 15 treatments and 3 replications. Amongst the various treatments, T_{13} [Popcorn maize (100% RDN) + Rajmash (100% RDN) paired row 2:2] performed better than other treatments by producing number of leaves plant^{-1}, plant height (cm), dry matter accumulation (g), stem girth (g) of popcorn maize, along with plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1} and dry matter accumulation (g) of rajmash.

Key words *Popcorn maize, Rajmash, Intercropping, Row ratios, N levels, Growth, etc.*

Popcorn or popping corn is a type of corn which puffs up when it is heated in oil or by dry heat. Some natural types will pop, but the cultivated strain (*Zea mays everta* L.), which is a special kind of *flint corn*. It is a popular snack in the United States and other countries, and is particularly common in movie theaters. Maize popcorn is very popular as it is tasty, easy to carry and eat. It is a low cost snack and also has nutritional values. For obtaining nutritional security with food security intercropping of legumes in between the longer duration rabi maize offers a good option. Intercropping is attracting more interest in developed countries, primarily due to claims that it can provide increased yields in an environmentally sustainable manner. With rapid increase in population and less chance of bringing new land under cultivation, intercropping seems to be the only way to increase productivity and intensity land use. This situation warrants developing an appropriate technology of growing field crop in association with legumes without too much intercrops interference and competition. Intercropping of cereals with legumes has been popular in tropics due to its advantages for soil conservation, lodging resistance, weed control, yield increment, high crude protein percentage and protein yield (Mandal *et al*., 2014). For successful and profitable intercropping system, there must be proper ratio of component crops in order to avoid limitation of reduced plant population of base crop under traditional intercropping system. Rajmash is considered as an ideal crop for intercropping with maize owing to its comparative tolerance for shade and drought, efficient light utilization and less competitiveness for soil moisture. Hence, with an object to enhance the productivity of popcorn maize and rajmash under intercropping system, various row ratios and nitrogen levels were tried in the present investigation.

MATERIAL AND METHODS

The experiment was conducted during rabi 2008-09 at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute-Deemed University, Allahabad (Uttar Pradesh). The soil of the experimental plot was sandy loam an organic carbon content of 0.39 per cent, pH of 7.4 and the available NPK of the experimental plot were analyzed to be 185.5, 36 and 98 kg ha^{-1}, respectively. The experiment was laid out in a randomized block design with three replications having fifteen treatment combinations. The treatment consisted of two intercropping systems *viz*., conventional

Table 1. Growth attributes of popcorn maize and rajmash as influenced by different treatments under intercropping system

Treatments	Popcorn maize					Rajmash		
	Plant height (cm)	Number of leaves plant^{-1}	Dry weight plant^{-1} (g)	Stem girth plant^{-1} (cm)	No. of cobs plant^{-1}	Plant height plant^{-1} (cm)	No. of branches plant^{-1}	Dry weight plant^{-1} (g)
T_1 Maize (100% RDF) Conventional sole	167.53	9.44	246.94	1.98	1.89	-	-	-
T_2 Maize (100% RDF) Paired row sole	169.47	11.22	249.19	2.19	2.22	-	-	-
T_3 Rajmash (100% RDF) Conventional sole	-	-	-	-	-	24.71	6.15	21.46
T_4 Maize (100% RDN) + Rajmash (100% RDN) Conventional 2:1	168.31	10.11	247.79	1.99	1.89	23.86	5.22	20.84
T_5 Maize (75% RDN) + Rajmash (100% RDN) Conventional 2:1	165.79	8.44	245.08	1.71	1.11	23.11	4.66	20.29
T_6 Maize (100% RDN) + Rajmash (75% RDN) Conventional 2:1	167.89	9.78	247.29	2.03	1.66	21.99	3.66	19.42
T_7 Maize (100% RDN) + Rajmash (100% RDN) Conventional 2:2	169.03	10.66	248.74	2.19	2.11	24.19	5.55	21.23
T_8 Maize (75% RDN) + Rajmash (100% RDN) Conventional 2:2	166.29	8.78	245.81	1.75	1.22	23.16	4.89	20.55
T_9 Maize (100% RDN) + Rajmash (75% RDN) Conventional 2:2	168.70	10.33	248.10	2.07	1.89	22.79	4.33	19.82
T_{10} Maize (100% RDN) + Rajmash (100% RDN) Paired row 2:1	170.15	11.66	249.93	2.30	2.77	27.06	8.00	22.44
T_{11} Maize (75% RDN) + Rajmash (100% RDN) Paired row 2:1	166.62	9.00	246.09	1.84	1.33	25.38	6.66	21.64
T_{12} Maize (100% RDN) + Rajmash (75% RDN) Paired row 2:1	169.84	11.44	249.55	2.24	2.44	26.66	7.22	22.11
T_{13} Maize (100% RDN) + Rajmash (100% RDN) Paired row 2:2	170.64	12.33	250.68	2.45	3.33	28.16	8.66	22.76
T_{14} Maize (75% RDN) + Rajmash (100% RDN) Paired row 2:2	167.09	9.22	246.53	1.95	1.55	26.19	7.00	22.00
T_{15} Maize (100% RDN) + Rajmash (75% RDN) Paired row 2:2	170.39	12.11	250.33	2.36	3.11	27.92	8.33	22.59
S. E. (±)	0.74	0.27	0.27	0.05	0.13	0.14	0.09	0.12
C. D. at 5%	1.52	0.55	0.56	0.10	0.26	0.28	0.18	0.26

intercropping of popcorn maize + rajmash (2:1 and 2:2 row ratios) where the row to row distance between the popcorn maize rows was 60 cm and paired row intercropping with two cropping systems of popcorn maize + rajmash (2:1 and 2:2 row ratios) where the row to row distance between the two paired rows was reduced to 40 cm and the distance between two paired rows was maintained at 80 cm, along with three nitrogen levels i.e. 100 % RDN to popcorn maize + 75 % RDN to rajmash, 75 % RDN to popcorn maize + 100 % RDN to rajmash and 100 % RDN to popcorn maize + 100 % RDN to rajmash and the observations were compared to paired rows sown sole popcorn maize, conventional sown sole popcorn maize and sole rajmash each fertilized with 100 % RDN. The recommended dose of NPK for popcorn maize was 150:80:60 kg NPK ha^{-1} and for rajmash was 120:60:40 kg NPK ha^{-1}, respectively. Sowing was done on 6th Nov. 2008. Thinning and gap filling was done at 15 days after sowing in both the crops to keep the plant to plant spacing of 25 cm in popcorn maize and 10 cm in rajmash. The crops were fertilized according to treatment details and

phosphorus and potassium were as blanket dose in all the treatments. Nitrogen was applied through urea, phosphorus through single super phosphate and potassium through muriate of potash. One-third nitrogen along with full dose of phosphorus and potassium were applied as basal and remaining dose of nitrogen was applied in two splits *viz*., first at knee-high stage (35 DAS) and second at pre-tasseling stage in popcorn maize. In rajmash, half nitrogen was applied basally and half was applied at 40 days after sowing. In popcorn maize and rajmash intercropping system number of leaves plant^{-1}, plant height (cm), dry matter accumulation (g) and stem girth (g) of popcorn maize, along with plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1} and dry matter accumulation (g) of rajmash were analyzed.

RESULT AND DISCUSSION

Popcorn maize: A perusal of the Table 1 clearly shows that the plant height in treatment T_{13} [Popcorn maize (100% RDN) + Rajmash (100% RDN) Paired row 2:2] was the highest and was statistically at par to the treatment T_2 [Popcorn maize (100% RDN) Paired row sole],T_{10} [Popcorn maize (100% RDN) + Rajmash (100% RDN) Paired row 2:1], T_{12} [Popcorn maize (100% RDN) + Rajmash (75% RDN) Paired row 2:1] and T_{15} [Popcorn maize (100% RDN) + Rajmash (75% RDN) Paired row 2:2]. Number of leaves, stem girth and dry matter accumulation were highest in treatment T_{13} [Popcorn maize (100% RDN) + Rajmash (100% RDN) Paired row 2:2] and were statistically at par to the treatment T_{15} [Popcorn maize (100% RDN) + Rajmash (75% RDN) Paired row 2:2].

The maximum plant height, number of leaves, stem girth and dry matter accumulation were obtained in 2:2 paired row system of planting as compared to conventional sowing which might be due to better nutrient uptake and dry matter accumulation as a result of minimum shading effect of maize. Plant height tended to increase or the nitrogen rate increased because nitrogen might have brought about vegetative growth in maize. Thavaprakash *et al*. (2005) reported that the wider row spacing had taller plants due to better availability of resources. Wider space availability between the rows might have increased the root spread which eventually utilized the resources such as water, nutrients, space and light very effectively. The higher number might be due to better sunlight receptivity by the maize plants sown in paired row sown at a greater distance as compared to conventional sowing and hence higher photosynthesis and better plant growth and higher number of leaves per plant. Singh and Verma (2002) reported that sufficient supply of nitrogen favoured the rate of photosynthesis by increasing leaf area, stem girth and crop growth, which ultimately produced more photosynthetic material in the form of carbohydrates. Cardoso *et al.,* (2007) reported that increase in NPK uptake by maize and rajmash under paired row intercropping system with increasing levels of fertilitilizers to main and intercrop may be due to increased dry matter production and secondly due to increased N, P and K contents of plants due to greater availability of their nutrients in the root zone and absorption by crops. The paired row sown maize intercrop with rajmash and both fertilized with 75% RDN did not have might higher stem girth because of absence of nodulation in rajmash in plains due to which it has a higher nitrogen requirement as of maize which might have resulted in mutual competition in both the crops as compared to those intercropping systems where both maize and rajmash have been provided with 100% of their RDN.

Rajmash: Amongst the intercropping treatment the plant height, number of branches and dry mater accumulation in treatment T_{13} [Popcorn maize (100% RDN) + Rajmash (100% RDN) Paired row 2:2] were the highest. Plant height and dry matter accumulation were statistically at par to the treatment T_{15} [Popcorn maize (100% RDN) + Rajmash (75% RDN) Paired row 2:2]. Rana *et al.,* 2001 reported that maximum plant height was obtained in 2:2 paired row system of planting as compared to conventional sowing might be due to better nutrient uptake and dry matter accumulation as a result of minimum shading effect of maize. Better sunlight receptivity by rajmash due to paired row sowing of maize plants sown at a greater distance as compared to conventional sowing and hence higher photosynthesis and higher dry matter accumulation. Similar results also reported by Tsubo and Walkar, 2004 and Mazaheri D., 2004.

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