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EFFECT OF ZERO TILLAGE BASIN PLANTING AND N NUTRITION ON GROWTH, YIELD, WATER PRODUCTIVITY AND NITROGEN USE EFFICIENCY OF LATE PLANTED BROCCOLI IN NORTH EAST HILLY REGION OF INDIA

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Abstract- Broccoli (*Brassica oleracea* L. var. italica) is emerging as a new cash crop in India where it is grown as rabi season vegetable crop and fetches very high price. A field experiment was conducted at the Agronomy Experimental Farm, Division of Natural Resource Management, ICAR (RC) NEH Region for Tripura centre, West Tripura, to see the effect of zero tillage basin planting and N nutrition on growth, yield, water productivity and nitrogen use efficiency of late planted broccoli. The experimental design was a split plot replicated three times. The experiments consisted of four methods of planting (main plots) and four levels of nitrogen (sub-plots). Zero tillage basin planting system recorded lowest plant mortality, consume less water, highest head formation ratio, curd weight (g), compactness coefficient (g cm-1), marketable plant biomass (t ha-1), marketable yield (t ha-1), nitrogen use efficiency (kg marketable yield kg-1 N applied) and water productivity (kg marketable yield m-3). Besides that it was also saves 71.2% water over flat bed planting system. Application of 180 kg N ha-1 was significantly superior in improving the head formation ratio, curd weight (g), compactness coefficient (g cm-1), marketable plant biomass (t ha-1), marketable yield (t ha-1) and water productivity (kg marketable yield m-3), however, nitrogen use efficiency (kg marketable yield kg-1 N applied) was higher with 60 kg N ha-1. Our study showed, the zero tillage basin planting with 180 kg N ha-1 is an alternative system for small holder farmers of North East India for growing late planted broccoli under limited water availability.

Keywords- basin planting, broccoli, marketable yield, head formation ratio, nitrogen use efficiency, water productivity, zero tillage

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) is emerging as a new cash crop in India where it is grown as *rabi* season vegetable crop and fetches very high price. Broccoli is high in antioxidant and anticancer compounds [1]. Growing broccoli in rice fallow is one of the good option for the small holder farmers of north east hilly region of India. Most of the fields remain vacant after harvest of rice from December to March due non availability of sufficient irrigation water. Only tap water or small jalkund water is available for irrigation. Hence, an alternate method of planting is required to save water and give sufficient yield with small amount available irrigation water. Hence, we tested a hypothesis that zero tillage basin planting method gave the same yield as compared to convention planting system under limited irrigation water. Planting of broccoli in December and afterward is considered as late planted crop. The late planted broccoli is affected by high temperature at the head formation stage. Hence, the hypothesis that, application of N may increase the head formation and yield in late planted broccoli was explored.

Materials and Methods

Growth Conditions

A field experiment conducted at the Agronomy Experimental Farm, Division of Natural Resource Management, ICAR (RC) NEH Region for Tripura centre, West Tripura at a latitude of 22°56' and 24°32 N, longitude of 91°10' and 92°21 E. during winter (*rabi*) season of 2011 -12. The research field is situated in a subtropical and the temperate climatic zones. The region is dominated by the monsoon season. The climate of the state is hot in summers and cold in winters with the temperatures ranging from 35°C to 10°C and receives an average rainfall of 2,100 mm. The soil of the experimental plot is sandy loam in texture, medium in available nitrogen (382.5 kg ha^{-1}), phosphorus (51 kg ha^{-1}) and potassium (247 kg ha^{-1}).

Main field was ploughed with power tiller and leveled after harvest of preceding crop under conventional tillage (CT) system. Ridge and furrow was made at 50 cm spacing from top to top of ridge in case of ridge planting and 50 cm spacing from middle of one furrow to other under furrow planting system. Glyphosate was used 2 ml l^{-1} under zero tillage system to control weeds 10 days before preparation of basin. Basin was made with 30 cm upper dia, 20 cm lower dia and 10 cm central depth. Ten t FYM ha^{-1} was applied before last ploughing under convention tillage system and ridge and furrow was made. In zero tillage system FYM was applied in basin only, one day before transplanting along with the recommended dose of P (52 kg ha^{-1}) and K (66.4 kg ha^{-1}) for all the treatments. Nitrogen was applied in three split dose. One third was applied as basal and remaining was top dressed in two equal parts at 20 and 40 DAT. Thirty days old Broccoli seedlings were planted in crop geometry of 0.60 m x 0.60 m in zero tillage basin planting system and 0.50 m x 0.50 m under conventional tillage planting system. Broccoli was sown at the beginning of December, planted on January 4 and harvested on March 19. Crop was irrigated 3-4 days interval through tap water as per climatic condition. Irrigation water was applied in furrow under ridge and furrow planting system and in basin under basin planting system. Irrigation water was applied to whole field under flat bed planting system. In initial stages of crop, the depth of water in furrow and basin planting system was very less to avoid

the damage of seedlings through standing water. Each plot covered an area of 8.4 m^2 (3.50 m x 2.40 m) and having 28 plants with 0.50 m x 0.50 m spacing and 24 plants with 0.60 m x 0.60 m spacing. All the agronomic and plant protection measures were adopted as per package of practice when necessary. Observations on different growth and yield attributes were recorded from five randomly sampled plants from each replication.

Experimental Design

The experimental design was a split plot replicated three times. The experiments consisted of four methods of planting (main plots) and four levels of nitrogen (sub-plots). The methods of planting treatments consisted of flat bed planting, ridge planting, furrow planting under convention tillage system and basin planting under zero tillage system. Planting geometry is also different in basin planting system compared to other methods of planting. Four levels of nitrogen (N) were studied as 0, 60, 120 and 180 kg N ha^{-1}.

Determination of Yield and Analysis

Total no of head and non head plant was counted at harvest. Head formation ratio was calculated as a head formed plant divide by the total plant population at harvest. Plant mortality (%) was calculated from plant population at harvest and at the time of transplanting. The broccoli at marketable maturity was collected from five center rows (20 samples) in CT and four center rows (16 samples) in ZT of a plot. Heads were individually graded for the determination of average head weight and total marketable yield for each plot. Irrigation water was measured in each plot using stop watch and converts that time in to water quantity of irrigation. Summation of each irrigation gave the total water used and expressed as m^3 ha^{-1}.Water productivity (WP) was calculated as total biomass/marketable broccoli yield divided by the water used [8]. Nitrogen use efficiency (NUE) was calculated as total marketable broccoli yield divided by the amount of N in different treatments [2]. All the data were analyzed using of variance (ANOVA). The least significant test (LSD) was used to compare and rank treatments [7]. Differences were declared significant at $p < 0.05$.

Result and Discussion

Plant Population and Head Formation Ratio

There was a significant difference in plant population at harvest among the methods of planting. The highest plant population was recorded with flat bed and ridge planting methods as compared with furrow and basin planting system. The plant population in basin planting system was low due to the more spacing (0.60 m x 0.60 m) that accommodated only 22848 plant ha^{-1} as compared to other methods (26656 plant ha^{-1}) at the time of transplanting [Fig-1a]. Application of N 180 kg ha^{-1} recorded the highest number of plant ha^{-1} and nitrogen also showed the linear relationship with plant population [Fig-2a]. Plant mortality was significantly low with zero tillage basin planting system as compared to other methods of planting. Furrow planting recorded highest plant mortality [Fig-1b]. Application of increasing rate of nitrogen significantly reduced plant mortality, and 180 kg N ha^{-1} recorded lowest plant mortality. Nitrogen levels showed inverse linear relationship with plant mortality [Fig-2b]. Head formation ratio (HFR) indicated the proportion of head formed plant in total plant at harvest. The non-significant effect of planting methods on HFR showed that Zero tillage Basin planting method was not inferior as compared to other planting methods [Fig-1c].

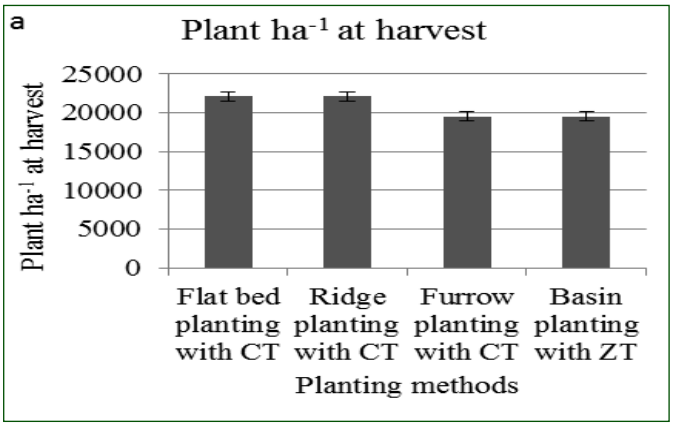

Fig. 1a- Effect of planting methods on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

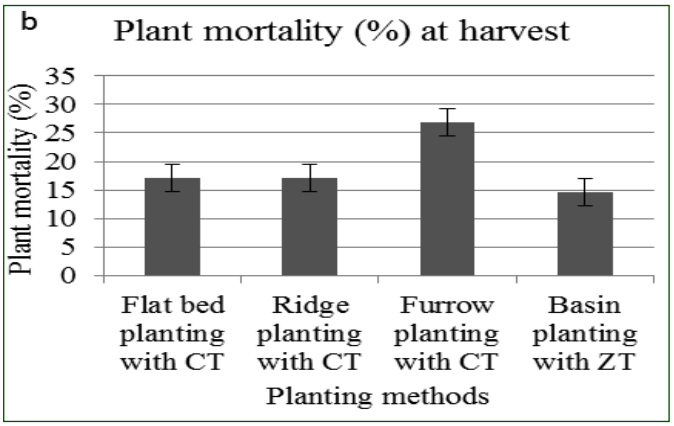

Fig. 1b- Effect of planting methods on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

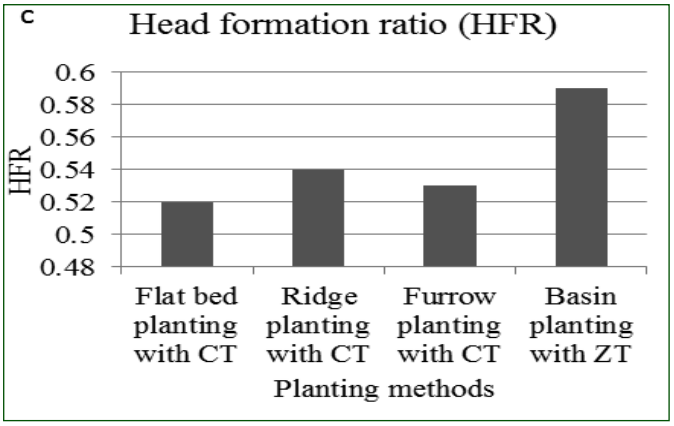

Fig. 1c- Effect of planting methods on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

Application of different levels of N showed a significant quadratic relationship (R^2=0.999) with HFR. Application of N 180 kg ha^{-1} recorded highest HFR, which was statistically at par with 120 kg N ha^{-1} as compared to other levels of N [Fig-2c]. The study clearly showed that increasing the levels of N increased the proportion of head formed plant as compared to non head formed plant in late planted broccoli. Linear increase in plant height in broccoli with increase in the level of nitrogen was also reported by Singh & Singh [10]. In

general, growth characters registered cumulative increase with increase in nitrogen fertigation levels. It may be due to the fact that increased supply of nitrogen accelerates synthesis of chlorophyll and amino acids, which play an important role in the growth and metabolism in plants [5]. Positive influence of cent percent fertigation of recommended dose of N & K (75:60 kg ha^{-1}) on growth and yield parameters of tomato was also reported by Brahma, et al [3,4].

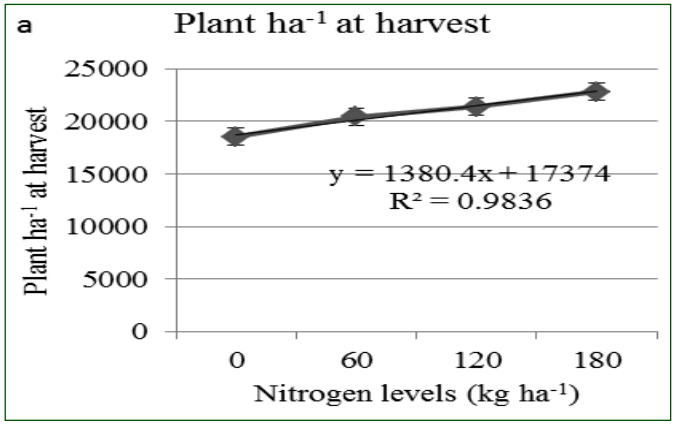

Fig. 2a- Effect of nitrogen levels on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

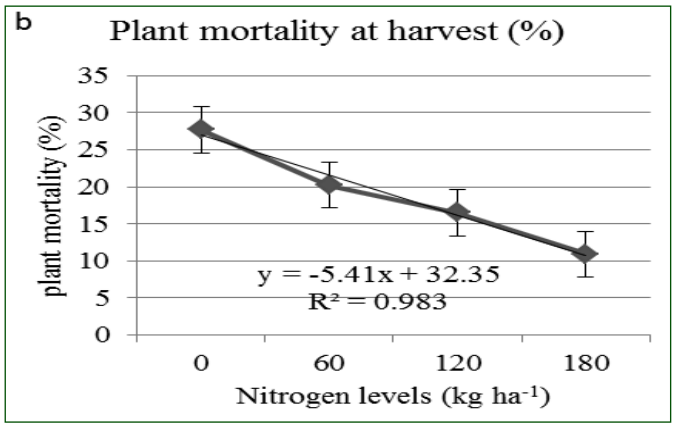

Fig. 2b- Effect of nitrogen levels on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

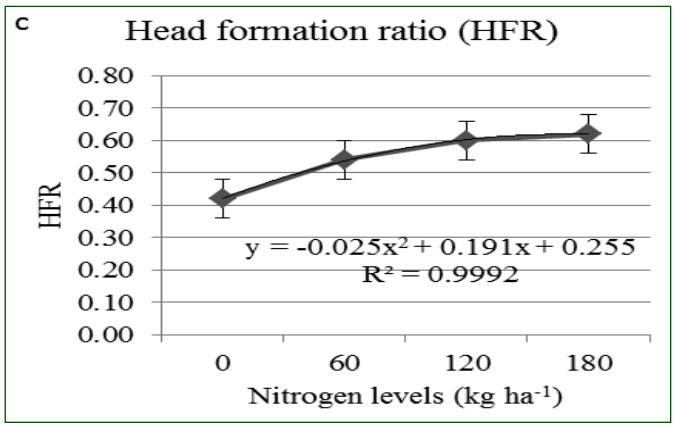

Fig. 2c- Effect of nitrogen levels on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

Yield Component and Yield

There was a significant effect of methods of planting and nitrogen application on yield component and yield of late planted broccoli [Table-1]. Flat bed planting with conventional tillage (CT) recorded highest curd weight (313 g) and compactness coefficient (19.5 g cm $^{-1}$), which was statistically at par with zero tillage basin planting as compared to other methods of planting. Curd diameter was not significantly affected by the methods of planting. Zero tillage basin planting methods produced significantly higher marketable plant biomass (10.64 t ha^{-1}) and marketable yield (3.73 t ha^{-1}), which was statistically on par with flat bed with CT. However, total biomass yield was not affected by the methods of transplanting. Culled plant biomass was highest with ridge planting and furrow planting system compared to flat bed and basin planting system. Increased levels of N application increased the all yield component and yield of broccoli. The increase in marketable yield of broccoli with increasing level of nitrogen fertigation could be attributed to improved vegetative growth, better availability of nutrients at vital growth period and greater synthesis of carbohydrates and their translocation to the storage organs [3,4]. Application of N increased the curd weight (30.1 - 68.4%), curd diameter (9.2 - 21.8%), compactness coefficient (21.9 - 41.8%), marketable plant biomass (80.1 - 198.9%), culled plant biomass (14.7 - 46.3%), total plant biomass (46.2 - 112.2%) and marketable yield (81.1 - 201.2%) over control (no nitrogen application) in late planted broccoli. These results clearly depicted that the nitrogen is one of the most important nutrient in late planted broccoli. Central head weight per plant and marketable yield of broccoli increased significantly with every increment in the level of nitrogen fertigation. Better utilization of nitrogen by the plants improved the photosynthetic efficiency, causing more production of carbohydrates and its conversion to amino acids and proteins might have allowed the plants to grow faster with increased plant vigour and spread [3,4]. Thompson, et al [11] also found that maximum marketable broccoli yields occurred at N rates of 300 - 500 kg ha^{-1}.

Nitrogen Use Efficiency (NUE), Water Use (WU), Water Saving (WS) and Water Productivity (WP)

Zero tillage basin planting method improved the NUE, WS, WP and reduced WU significantly as compared to other methods of planting [Table-2]. NUE under different methods of planting varied widely and highest reported by basin planting with zero tillage (21.4 kg marketable yield kg^{-1} N applied). NUE varied from 8.7 - 21.4 kg marketable yield kg^{-1} N applied. The increased NUE was mainly due to higher marketable yield under zero tillage basin planting system. The NUE decreased with increasing in N applications and the highest NUE value was obtained from application of 60 kg N ha^{-1} treatment. Nitrogen use efficiency decreased (22.2 - 18.3 kg marketable yield kg^{-1} N applied) with increased levels of N from 60 - 180 kg ha^{-1}. Lowest was recorded with application 180 kg N ha^{-1}. A similar result was also reported by Erdem, et al [6]. Flat bed planting system consumed highest amount of water (6966 m^3 ha^{-1}) as compared to other planting methods. Zero tillage basin planting used less amount of water and saved 71.2% water over flat bed system. WP varied widely among the methods of planting and highest was reported by zero tillage basin planting system (7.61 kg biomass m^{-3} and 1.93 kg marketable yield m^{-3}). Water use and water productivity increased with increased levels of nitrogen application over control. The highest water use 4024 m^3 ha^{-1} recorded with application of N 180 kg ha^{-1}. Water saving was not affected by N

application. Application of N increased the WP (4.88 - 6.26 kg biomass m^{-3} and 1.06 - 1.63 kg marketable yield m^{-3}) as compared to control (3.45 kg biomass m^{-3} & 0.60 kg marketable yield m^{-3}). López -Urrea, et al [9] reported that the highest WUE and IWUE were 4.32 kg m^{-3} & 14.61 kg m^{-3} for the spring cultivation, respectively. These values were 1.43 kg m^{-3} & 5.93 kg m^{-3} for the autumn cultivation, respectively. López-Urrea, et al [9] noticed that the WUE of broccoli varied between 2.08 kg m^{-3} & 3.09 kg m^{-3} in the Central Spain.

Our study showed, the zero tillage basin planting with 180 kg N ha^{-1} was enhanced the marketable yield, water productivity and save 71.2% water over flat bed planting with conventional tillage. Study revealed, it is an alternative system for small holder farmers of North East India for growing late planted broccoli under limited water availability.

Table 1- Effect of Zero tillage basin planting and N nutrition on non-head plant, head plant, head weight, diameter and compactness coefficient of late planted broccoli

Treatment	Head (Curd) weight (g)	Diameter (cm)	Compactness coefficient (g cm^{-1})	Marketable plant biomass (t ha^{-1})	Culled plant biomass (t ha^{-1})	Total plant Biomass (t ha^{-1})	Marketable Yield (t ha^{-1})
Methods of planting							
Flat bed planting with CT	313	16	19.5	10.62	4.99	15.82	3.71
Ridge planting with CT	274	15.2	17.9	8.64	5.94	14.51	3.02
Furrow planting with CT	254	16.5	15.3	8.62	5.42	13.99	3.02
Basin planting with ZT	299	15.3	19.2	10.64	4.77	14.65	3.73
SEm±	7	0.3	0.8	0.3	0.17	0.37	0.12
LSD (p=0.05)	25	NS	2.9	1.05	0.6	NS	0.42
Nitrogen nutrition							
0 kg ha^{-1}	209	14.2	14.6	4.72	4.34	9.24	1.64
60 kg ha^{-1}	272	15.5	17.8	8.5	4.98	13.51	2.97
120 kg ha^{-1}	306	16	18.9	11.19	5.44	16.61	3.92
180 kg ha^{-1}	352	17.3	20.6	14.11	6.35	19.61	4.94
SEm±	9	0.5	0.8	0.47	0.19	0.62	0.16
LSD (p=0.05)	25	1.3	2.4	1.36	0.56	1.8	0.45

Table 2- Effect of Zero tillage basin planting and N nutrition on nitrogen use efficiency (NUE), water use and water productivity of late planted broccoli

Treatment	NUE (kg marketable yield kg^{-1} N applied)	Water use (m^3 ha^{-1})	Water saving (%)	Water productivity (kg biomass m^{-3})	Water productivity (kg marketable yield m^{-3})
Methods of planting					
Flat bed planting with CT	13.5	6966	0	2.37	0.55
Ridge planting with CT	16	3805	45.4	3.82	0.82
Furrow planting with CT	8.7	2372	66	6.43	1.33
Basin planting with ZT	21.4	2004	71.2	7.61	1.93
SEm±	1	30	0.4	0.11	0.07
LSD (p=0.05)	3.6	103	1.5	0.37	0.23
Nitrogen nutrition					
0 kg ha^{-1}	0	3544	46.3	3.45	0.6
60 kg ha^{-1}	22.2	3712	45.7	4.88	1.06
120 kg ha^{-1}	19	3866	45.3	5.64	1.34
180 kg ha^{-1}	18.3	4024	45.3	6.26	1.63
SEm±	1.6	46	0.3	0.24	0.06
LSD (p=0.05)	4.7	135	NS	0.7	0.17

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