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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 (*Brassica oleracea* var *italica*) in North East Hilly Region of India

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Broccoli (*Brassica oleracea* L. var. *italica*) is a *rabi* season vegetable, fetching high price, emerging as new cash crop in India. Broccoli is high in antioxidant and anticancer compounds (Agarwal *et al*. 2007). Small and marginal farmers of NEH have good option to take broccoli after rice. Deficit of irrigation water during December to March except some tap water or small jalkund water appeals to the farmer for water saving technique to raise the crop, and alteration in planting technique may help to save water without yield penalty under limited irrigation source. Zero tillage basin planting is one of the option to save water, thus it is hypothesize that this planting technique would be better than conventional planting system under limited irrigation water. Late planting of broccoli, i.e after December suffers high temperature stress during head formation stage, and increase in nitrogen doses may endure the heat stress and may cause more head formation . Considering above an investigation was done to see the effect of planting techenique and nitrogen doses on broccoli crop

During rabi season of 2011-12, a field experiment was conducted at the Agronomy Experimental Farm, Division of Natural Resource Management, ICAR (RC) NEH Region for Tripura centre, West Tripura. The experimental site was situated at a latitude of 22°56' and 24°32 N, longitude of 91°10' and 92°21 E. 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), phosphorus (51 kg/ha) and potassium (247 kg/ha). 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). Planting method consisted 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. 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 under zero tillage system to control weeds 10 days before preparation of basin. Basin was made with 30 cm upper diameter, 20 cm lower diameter and 10 cm central depth. Ten tonnes of FYM/ha was applied before last ploughing under conventional 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) and K (66.4 kg/ha) 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 days after transplanting (DAT). Thirty days old broccoli seedlings were planted in crop geometry of 0.60 m × 0.60 m in zero tillage basin planting system and 0.50 m × 0.50 m under conventional tillage planting system. Broccoli was sown at the beginning of December, planted on 4 January and harvested on 19 March. 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

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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 × 2.40 m) and having 28 plants with 0.50 m × 0.50 m spacing and 24 plants with 0.60 m × 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.

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 × 0.60 m) that accommodated only 22848 plant/ha as compared to other methods (26656 plant/ha) at the time of transplanting (Fig 1a). Application of N 180 kg/ha recorded the highest number of plant/ha 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 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

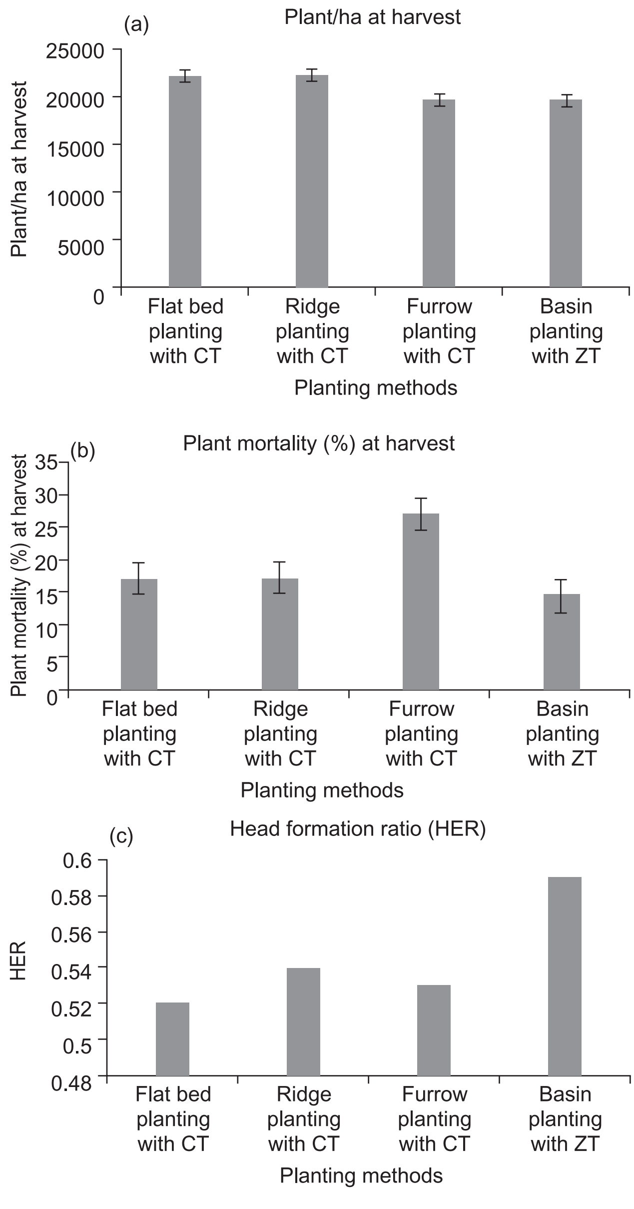

Fig 1 Effect of planting methods on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

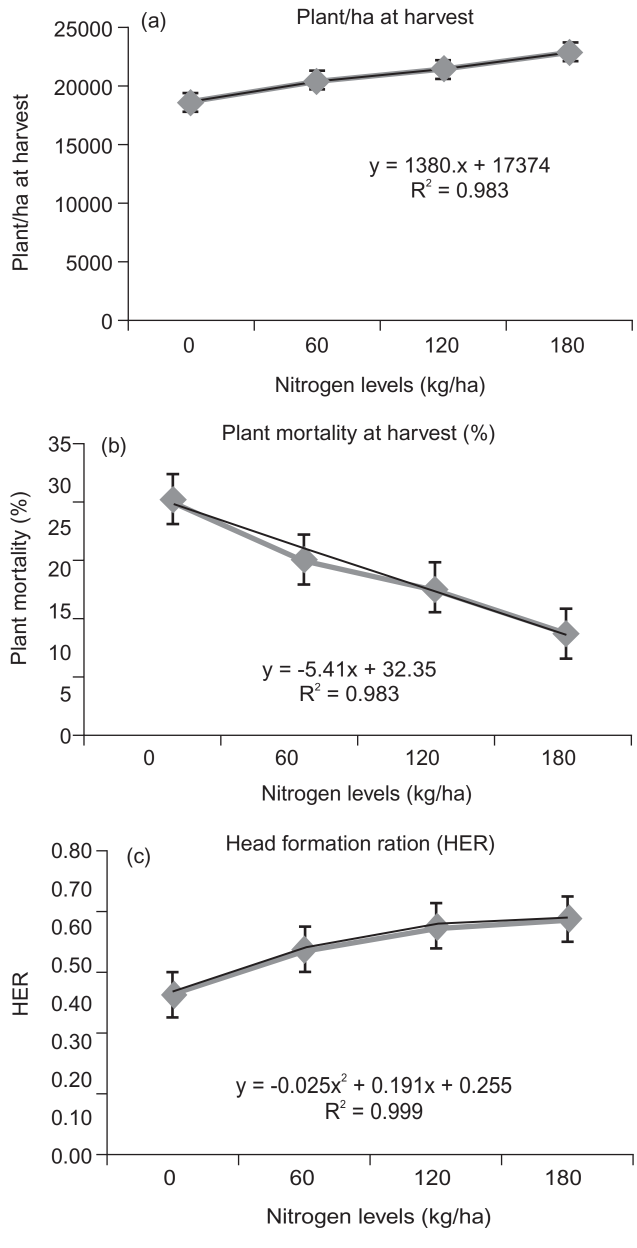

Fig 2 Effect of nitrogen levels on plant population, pant mortality and HFR of late planted broccoli. Standard error bars indicated the CD value

compared to other planting methods (Fig 1c). Application of different levels of N showed a significant quadratic relationship (R^2=0.999) with HFR. Application of N 180 kg/ha recorded highest HFR, which was statistically at par with 120 kg N/ha 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 and Singh (2000). 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 (Devlin 1973). Positive influence of cent percent fertigation of recommended dose of N and K (75:60 kg/ha) on growth and yield parameters of tomato was also reported by Brahma *et al.* (2010).

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), 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 tonnes/ha) and marketable yield (3.73 tonnes/ha), 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 (Brahma *et al*. 2010). 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 (Brahma *et al*. 2010). Thompson *et al*. (2002) also found that maximum marketable broccoli yields occurred at N rates of 300-500 kg/ha.

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 N applied). NUE varied from 8.7-21.4 kg marketable yield/kg 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 treatment. Nitrogen use efficiency decreased (22.2-18.3 kg marketable yield/kg N applied) with increased levels of N from 60-180 kg/ha. Lowest was recorded with application 180 kg N/ha. A similar result was also reported by Erdem *et al*. 2010. Flat bed planting system consumed highest amount of water (6966 m^3/ha) as

Table 1 Effect of Zero tillage basin planting and N nutrition on yield attributes and yield of late planted broccoli

Treatment	Head (Curd) weight (g)	Diameter (cm)	Compactness coefficient (g/cm)	Marketable plant biomass (tonnes/ha)	Culled plant biomass (tonnes/ha)	Total plant biomass (tonnes/ha)	Marketable yield (tonnes/ha)
Methods of planting							
Flat bed planting with CT	313	16.0	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	0.30	0.17	0.37	0.12
LSD (P=0.05)	25	NS	2.9	1.05	0.60	NS	0.42
Nitrogen nutrition							
0 kg/ha	209	14.2	14.6	4.72	4.34	9.24	1.64
60 kg/ha	272	15.5	17.8	8.50	4.98	13.51	2.97
120 kg/ha	306	16.0	18.9	11.19	5.44	16.61	3.92
180 kg/ha	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	1.80	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 N applied)	Water use (m^3/ha)	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	0.0	2.37	0.55
Ridge planting with CT	16.0	3805	45.4	3.82	0.82
Furrow planting with CT	8.7	2372	66.0	6.43	1.33
Basin planting with ZT	21.4	2004	71.2	7.61	1.93
SEm±	1.0	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	0.0	3544	46.3	3.45	0.60
60 kg/ha	22.2	3712	45.7	4.88	1.06
120 kg/ha	19.0	3866	45.3	5.64	1.34
180 kg/ha	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	0.70	0.17

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 recorded with application of N 180 kg/ha. 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 and 0.60 kg marketable yield/m^3). Erdem *et al.* 2010 reported that the highest WUE and IWUE were 4.32 kg/m^3 and 14.61 kg/m^3 for the spring cultivation, respectively. These values were 1.43 kg/m^3 and 5.93 kg/m^3 for the autumn cultivation, respectively. Lopez-Urrea *et al*. (2009) noticed that the WUE of broccoli varied between 2.08 kg/m^3 and 3.09 kg/m^3 in the Central Spain.

SUMMARY

Our study showed, the zero tillage basin planting with 180 kg N/ha enhanced the marketable yield, water productivity in broccoli (*Brassica oleracea* L. var *italica*) 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.

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BOOK REVIEW

Food Security of India: An overview. 2014. Modgal, Suresh C. National Book Trust, India, Nehru Bhavan, 5 Institutional Area, Phase-II, Vasant Kunj, New Delhi 110070. First edition. xviii + 340 pp. 21.5 cm × 14 cm. ₹ 170. 1SBN 978-81-237-7131-1.

The Rome Declaration on World Food Security and the World Food Summit Plan of action convened in 1996 by the Food and Agriculture Organization of the United Nations expressed the accomplishment of food security when "all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". National Commission on Farmers in India in 2006 have further refined the concept of food and nutritional security by including social and environmental components to it.

India achieved self sufficiency in foodgrains production beginning 1967-68 as a result of the adoption of high yielding varieties of rice and wheat and related improved matching production technology. These new dwarf varieties were highly responsive to inputs like high doses of plant nutrients and irrigation and had a yield potential more than two to three times as compared to the tall traditional varieties. The country was so fed up with the prevailing "ship to mouth" food situation between 1947 and mid 1960s that whole lot of scientific agricultural infrastructure, official agencies of Union Government and state governments, all became super active to make new food production programme a success. Government of India committed to make the Right to Food a realty enacted the" National Food Security Act "and simultaneously creating 60 million new jobs between 2009-2014.

A multiplicity of factors influence food and nutritional security and the complexity of the situation increases when it pertains to 1.2 billion people. The book, therefore, deals with many natural and man-made factors like food production trends, nutritional aspects, the Public Distribution System and food trade. Modern science based food production technologies and their transfer to farmers, post-harvest care, natural and commercial resources, global warming and climate change, environmental degration, recession and economic slowdown, strategies for a sustainable food security and social issues involving food and nutritional security. Food security situation in South Asian region and global level, are also discussed.

The book emphasized on major reforms in the approach to existing policies related to the role of public and private sectors in the development process of agriculture and rural sectors. Importance of a renewed effort on partnership with the country's farmers in developing a competitive agri-business is discussed. This discussion includes the need for reviving the investment in agriculture and rural sectors as well as in R&D process for a sustainable food and nutritional security for all the citizens and more so for those households who lack the capacity to buy even subsidized food.

The book is useful for policy makers, teachers, scientists, students and general reader alike. The book is well produced by the NBT.

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