Vegetable Science (2017) 44 (1) : 86-92

Mulching and different levels of nitrogen and phosphorus improve yield and quality attributes of broccoli (*Brassica oleracea* var. *italica*) and physicochemical property of soil

Veerendra Kumar Verma*, Anjani Kumar Jha, Bibhash Chandra Verma, Priyajit Chaudhuri and David Nonglait

Received: March 2017 / Accepted: July 2017

Abstract

A field experiment was conducted on broccoli (*Brassica oleracea* var. *italic*) hybrid Puspa during *rabi* season of 2013-14 to 2015-16 under the mid-hills of Meghalaya. The effect of mulching, different levels of nitrogen and phosphorous on the physicochemical properties of soil, yield and quality attributes of broccoli were studied. The treatments were consisting of nine nutrient combinations having three doses of N (Urea) and P_2O_5 (SSP) with and without mulching. The experiment was conducted in factorial randomized block design with three replications. The observations were recorded for growth, yield and quality attributes of plants and physicochemical properties of soil. All the growth, yield and quality attributes except vitamin-C and â-carotene increases with the increase in dosage of N and P fertilization under mulching condition. The results of mulching also have shown significant improvement in soil fertility parameters as well as yield and quality attributing traits. The treatment comprises of mulch (10 t/ha) + FYM (10 t/ha) + $N_{120}P_{80}K_{60}$ gave higher gross plant weight (0.8 kg), marketable head weight (0.41 kg) and yield (16.6 t/ha) over the other treatments, could be recommended for the growers of the north eastern region for higher yield (18.4%) and profit.

Keywords: Broccoli, nitrogen, phosphorous, mulch, quality

Introduction

Broccoli (*Brassica oleracea* var. *italica*) is an important cole crop of the Nortth East region of India. Among cole crops, broccoli occupies prime position due to richness in protein, vitamins as well as in minerals. It is also rich in anti-carcinogenic substances such as indol-3-carbinol and sulforapahane. In valleys, it is grown at large scale during September to March on the raised bed, locally known as "bun". However, in the mid-hills, it is grown on small scale due to stress of soil moisture. Among the plant nutrients, nitrogen (N) has a high influence on plant growth and it is recognized as the most important nutrient for plant development, yield and quality (Lea and Azevedo 2006, Lopez-Berenguer et al. 2007). More than 50% of leaf N is in components associated with plant photosynthesis (Gastal and Lemaire 2002). Phosphorus stores and transfers energy within plants, and helps in increasing the crop productivity. The significant effect of nitrogen and phosphorous on yield and quality attributes has been observed in broccoli by Babik and Elkner (2002) and Belec et al. (2001). The soil of the region being acidic in nature, the crop growth is limited due to deficiency of phosphorus mainly by fixation. Moreover, a disorder "hollow stem" is also very common in the region due to imbalance uses of N.

The crops in the north eastern region is also suffers from moisture stress (abiotic) especially in mid-hills during the growing season which limit the yield and quality of the produce. To overcome the problem of moisture stress, mulching in vegetable crops has been found most effective means for the *in-situ* conservation of soil moisture. The reasons for their extended use include ability to grow plants at elevation of soil temperature and reduction of moisture loss, increased the net photosynthesis rate, delayed accumulation of salts, reduced loss of leaf relative water content (RWC), chlorophyll concentration and plant dry matter caused by stress, and improved size, yield, nutrients and antioxidants (Jasim et al. 2014), increases water use efficiency and caused better availability of mineral nutrients and amelioration of negative water stress (Kirnak and Demirtas 2006). Keeping above facts in view, the present study was carried out with the objectives to study

ICAR Research Complex for NEH Region, Umroi Road, Umiam-793103, Meghalaya
*Corresponding author, Email: verma.veerendra@gmail.com

the effect of mulching, and different dosage of N and P and mulch on soil water, thermal regime, and availability of nutrients and growth, yield and quality attributes of the broccoli.

Materials and Methods

This experiment was conducted during October-February for three years i.e. 2013-14 to 2015-16 at Horticulture Experimental Farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya. During 2015-16 the total annual rainfall of the place was 2551 mm with monsoon rainfall (June-September) of 1630 mm contributing 64% of the total rainfall. The highest rainfall (575.3 mm) received in the month of August and minimum (0.2 mm) in December. The maximum mean temperature varied between 29.0-26.6 ^{0}C for all the months except November to February when it varied from 24.5-19.8 ^{0}C. The minimum mean temperature was highest (19.2 ^{0}C) in the month of July and lowest (5.1 ^{0}C) in January. The experimental soil was sandy in texture with acidic reaction (pH: 5.4). The bulk density, soil organic carbon, available N, P, K, Ca and Mg were 1.46 g/cc, 2.01%, 182 kg/ha, 20.25 kg/ha, 298 kg/ha, 2.35 meq/100g and 0.65 meq/100g, respectively. The treatments were applied on the broccoli hybrid Puspa (Syngenta India Ltd) with two factors (nutrients and mulch). Total nine nutrient combinations (T_1: 80:60:60 T_2: 100:60:60 T_3: 120:60:60 T_4: 80:80:60 T_5: 100:80:60 T_6: 120:80:60 T_7: 80:100:60 T_8: 100:100:60 T_9: 120:100:60) having different doses of N (Urea) and P_2O_5 (SSP) and uniform doses of K (MOP) were applied with and without mulch treatment. The half dosage of N and full doses of P and K was given in the pits at the time of land preparation. FYM was also applied at the rate of 10 t/ha during land preparation uniformly. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. One month old seedlings were planted at 45 × 45 cm spacing. The mulching material (paddy straw) was used at 10 days after planting at the rate of 10 t/ha. The field was irrigated uniformly at 10-12 days intervals up to heading stage with drip. The observations were taken for growth parameters such as gross plant weight (kg), leaf length (cm), leaf width (cm), leaf weight per plant (g), marketable head weight (kg), stalk length (cm) and stalk weight (g), yield (q/ha) from the six plant in each treatments and quality parameters such as total sugar (%), crude protein (%) vitamin-C (mg/100g) and â-carotene(mg/100g) was estimated as described by Rangana (1977).

To study the changes in nutrient status *viz*. available nitrogen (N), phosphorous (P), potassium (K), organic carbon (OC), and pH were determine at before transplanting of the crop and after the harvesting in each treatments. The soil pH was determined in 1:2 (soil: water) suspension using combined electrode (glass and calomel electrodes) by digital pH meter. Soil organic carbon was determined following the method of Walkley and Black, available N by alkaline potassium permanganate method, available P by Bray's method and available K by ammonium acetate extraction method. The observations such as air and soil temperature were taken at three stages of plants and soil moisture at three stages i.e., first irrigation after mulching, heading and harvesting stage during year 2015-16. The mean data of each replication were analyzed using SAS software. The significance of the difference among the treatment combinations means was compared by DMRT test at $P<0.05$ level of probability.

Results and Discussion

Effect on growth and yield traits: The result of present investigation has revealed the significant improvement in yield attributing traits with increases in the dosage of N and P. Similarly, mulching has also shown significant effects for all the traits over the no mulch (Table 1). Comparing all treatments combinations under mulching and no mulching it was found that The highest gross plant weight (0.8 kg), leaf number (7.3), leaf weight (302.3 g), leaf length (40.2 cm), leaf width (18.5 cm), stalk length (9.5 cm), stalk weight (83.9 g) and marketable head weight (0.41 kg) was recorded from the treatment T_6 comprise of N_{120} P_{80} K_{60} under mulching condition. The second and third best treatments were T_9 (N_{120} P_{100} K_{60}) and T_3 (N_{120} P_{60} K_{60}) which are statistically at par with T_6 for the traits like leaf number, leaf weight, leaf length, leaf width, stalk length, stalk weight and also marketable head weight. Similarly, the yield per hectare was highest under the mulching from the treatment T_6(N_{120} P_{80} K_{60}). However, from the pooled mean data the highest yield 14.05 t/ha and 16.63 t/ha was recorded from the treatment T_6 (N_{120} P_{80} K_{60}) under the control and mulch conditions, respectively (Table 2). The probable reasons for increases in growth and yield attributing traits may be due to increases in the efficiency of N and P by mulching with higher dosage and the synergistic effect of nitrogen, phosphorus and potassium which are known to promote plant growth by virtue of their association in cell elongation, cell division, promotion of ADP activities, root development and regulating the stomatal activities in the leaves. The similar findings were also reported by Kumar et al. (2001), Katiyar et al. (2012) and Neethu et al. (2015) in broccoli. The mulching has also shown significant effect for all growth and yield attributing traits over the control.

Table 1: Effect of different dosage of fertilizers and mulch on yield attributing traits in broccoli

Fertilizer treatments	Gross plant wt. (kg)		Leaf number		Leaf wt. (g)		Leaf length (cm)		Leaf width (cm)		Stalk length (cm)		Stalk weight (g)		Marketable head wt. (kg)	
	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control
T_1	0.53^{c}	0.45^{d}	10.0^{b}	9.8^{b}	179.9^{d}	163.4^{c}	30.9^{d}	32.8^{ab}	15.8^{c}	15.9^{bc}	7.6^{b}	7.6^{b}	56.9	56.2	0.29^{d}	0.23^{c}
T_2	0.56^{c}	0.53^{abc}	10.3^{ab}	10.2^{ab}	196.3^{cd}	189.0^{abc}	36.6^{abc}	33.0^{ab}	16.8^{bc}	16.1 ^{abc}	8.3^{ab}	7.2^{ab}	66.4	50.9	0.30^{cd}	0.27^{abc}
T_3	0.66^{b}	0.54^{ab}	10.5^{ab}	10.0^{ab}	232.3^{bc}	198.2^{ab}	38.7^{ab}	33.6^{ab}	17.5^{bc}	16.8^{ab}	8.3^{ab}	7.5^{ab}	75.4	60.0	0.35^{abcd}	0.29^{abc}
T_4	0.56^{c}	0.47^{cd}	10.3^{ab}	9.6^{b}	195.2^{cd}	170.0^{c}	35.4^{bc}	30.9^{ab}	16.8^{ab}	15.7^{bc}	7.2^{b}	6.8^{b}	63.1	54.4	0.30^{cd}	0.25^{bc}
T_5	0.71^{b}	0.56^{a}	10.8^{ab}	10.6^{ab}	244.6^{b}	190.5^{abc}	40.2^{a}	34.3^{a}	17.6^{ab}	16.0^{bc}	9.4^{a}	8.5^{a}	83.9	74.3	0.38^{ab}	0.28^{abc}
T_6	0.80^{a}	0.59^{a}	11.3^{a}	11.3^{a}	302.3^{a}	211.0^{a}	38.7^{ab}	34.7^{a}	18.5^{a}	17.2^{a}	9.5^{a}	8.5^{a}	91.4	76.9	0.41^{a}	0.32^{a}
T_7	0.59^{c}	0.48^{bcd}	10.0^{b}	9.6^{b}	178.5^{d}	166.8^{c}	34.5^{cd}	32.4^{ab}	16.8^{bc}	15.2^{c}	7.8^{b}	7.4^{b}	78.3	57.3	0.31^{cd}	0.26^{bc}
T_8	0.58^{c}	0.53^{abc}	10.3^{ab}	10.3^{ab}	196.6^{cd}	180.0^{abc}	34.5^{cd}	29.7^{b}	17.8^{ab}	15.9^{bc}	8.9^{ab}	7.6^{ab}	68.3	64.9	0.33^{bcd}	0.28^{abc}
T_9	0.67^{b}	0.57^{a}	11.3^{a}	11.0^{ab}	230.9^{bc}	211.5^{a}	37.8^{abc}	34.8^{a}	17.9^{ab}	16.8^{ab}	8.6^{ab}	7.9^{ab}	80.8	68.8	0.35^{abc}	0.30^{ab}
LSD	0.10		1.08		39.79		3.93		1.81		1.29		13.73		0.62	

* Means with the same letter in column are not significantly different at P<0.05

Table 2: Effect of different dosage of fertilizers and mulch on yield (q/ha) of broccoli

Fertilizer Treatments	2013-14		2014-15		2015-16		Pooled		Increase in yield (%) under mulch over no-mulch
	Control	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	
T_1	9.50^{d}	12.05^{e}	9.93^{d}	11.74^{d}	10.10^{e}	11.37^{g}	9.84^{e}	11.72^{e}	19.11
T_2	9.62^{d}	12.26^{e}	11.74^{c}	11.96^{d}	11.11^{d}	12.08^{fg}	10.82^{cde}	12.10^{de}	11.83
T_3	12.30^{b}	16.03^{b}	11.91^{c}	14.02^{c}	11.64^{cd}	13.17^{de}	11.95^{bcd}	14.40^{bc}	20.50
T_4	10.16^{d}	12.08^{e}	10.28^{d}	11.92^{d}	10.97^{d}	12.36^{ef}	10.47^{dc}	12.12^{de}	15.76
T_5	12.27^{b}	15.35^{b}	12.22^{c}	15.05^{b}	11.98^{bc}	15.43^{a}	12.16^{bc}	15.27^{b}	25.58
T_6	13.93^{a}	16.96^{a}	14.60^{a}	16.50^{a}	13.62^{a}	16.43^{a}	14.05^{a}	16.63^{a}	18.36
T_7	11.28^{c}	13.35^{d}	10.20^{d}	13.50^{c}	11.51^{cd}	13.83^{cd}	10.99cde	13.56^{cd}	23.38
T_8	12.01^{b}	14.82^{c}	11.98^{b}	13.74^{c}	12.57^{b}	14.55^{b}	12.19^{bc}	14.37^{bc}	17.88
T_9	12.0^{b}	15.8^{b}	13.20^{c}	15.08^{b}	12.73^{b}	14.75^{bc}	12.68^{ab}	15.21^{ab}	19.95
Mean	11.45	14.30	11.78	13.72	11.80	13.77	11.68	13.93	19.26
LSD	0.70		0.90		3.90		1.60	1.56	-

* Means with the same letter in column are not significantly different at P<0.05

This probably may be due to increasing in the availability of the nutrients by improving the microclimate (temperature and moisture) regime of the soil in rhizosphere under the mulching conditions which leads to the acceleration in photosynthesis and pigments. The positive effects of mulching on growth and yield attributing traits were also reported by Kosterna (2014) and Ghurbat et al. (2016) in broccoli, and Singh et al. (2013) in tomato.

Effect on quality attributes: Among the cole crops, broccoli is known for its rich in nutritional value such as protein, â-carotene and vitamin-C content. The significant effect of the mulch and different dosage of N and P was observed for the different quality traits (Table 3). The highest total sugar was recorded from the treatment T_9 (2.01 and 1.90) and which was statistically at par with T_6 (1.96 and 1.73) under mulch and control conditions, respectively. Across the treatments, sugar content was higher in mulching condition over the control. The increase in sugar content due to mulching was also reported by Kostern (2014) in broccoli and tomato.

The highest protein content (2.79 and 2.82 g/100g) was also recorded from T_9 which was statistically at par with T_6 (2.77 and 2.83 g/100g) and T_3 (2.70 and 2.80 g/100g) under no mulch and mulch conditions, respectively. The protein content was significantly higher under mulching conditions over the control. Franczuk et al. (2009) also observed significant increase in protein content in cabbage under the mulching condition. The results have also indicated an increase in protein content with increases in dosage of N and P. The positive effect of N and P on the protein content has been reported by Khalid (2012), as it has an influence on the ribosome structure and the biosynthesis of hormones (gibberellines, auxins and cytokinins) which is involved in protein synthesis. An increase in available nitrogen contents stimulates protein production, which may increased protein content in broccoli. The fertilizer treatments and mulch has also shown significant effects on the â-carotene content. Among the treatments, the highest â-carotene 36.92 and 34.80 mg/100g was observed from the treatment T_6 under no mulch and mulching conditions, respectively and it was statistically

Table 3: Effect of different dosage of fertilizers and mulch on quality attributes in broccoli

Fertilizer treatments	Total sugar (%)		Protein (%)		β-Carotene (mg/100g)		Vitamin-C (mg/100g)	
	Mulch	Control	Mulch	Control	Mulch	Control	Mulch	Control
T_1	1.63^{bc}	1.65^{bc}	2.53^{c}	2.24^{c}	32.16^{b}	33.93^{bc}	66.8^{b}	85.2^{b}
T_2	1.66^{b}	1.60^{bc}	2.77^{ab}	2.54^{b}	32.63^{b}	35.10^{b}	65.4 ^{b}	81.6^{c}
T_3	1.78^{b}	1.66^{bc}	2.80^{a}	2.70^{a}	33.30^{a}	34.29^{bc}	61.6^{d}	69.6^{f}
T_4	1.74^{b}	1.61^{bc}	2.71^{abc}	2.50^{b}	32.96^{b}	33.37^{cd}	69.6^{a}	89.3^{a}
T_5	1.75^{b}	1.64^{bc}	2.76^{ab}	2.55^{b}	30.13^{c}	32.03^{d}	66.2^{b}	74.8^{d}
T_6	1.96^{a}	1.73^{ab}	2.83^{a}	2.77^{a}	34.80^{a}	36.92^{a}	57.6^{e}	66.2^{g}
T_7	1.47^{c}	1.52^{c}	2.60^{bc}	2.51^{b}	31.59^{b}	32.70^{cd}	70.2^{a}	72.0^{e}
T_8	1.70^{b}	1.64^{bc}	2.65^{abc}	2.61^{b}	32.71^{b}	33.10^{bc}	63.3^{c}	69.1^{f}
T_9	2.01^{a}	1.90^{a}	2.82^{a}	2.79^{a}	33.85^{ab}	37.16^{a}	57.8^{e}	61.2^{g}
LSD	0.18		0.19		1.69		1.67	

* Means with the same letter in column are not significantly different at P<0.05

at par with T_3 under the mulching and T_9 under both the conditions. The result has also indicated the significant increases in the â-carotene content with the increases in dosage of N and P. The similar findings were also reported by Chenard et al. (2005) in parsley and Boskovic-Rakocevic et al. (2012) in carrot. â-carotene is synthesized in chloroplast and the amount of chloroplast is influence by the supply of N. The â-carotene content was also significantly affected by the mulching treatments; the higher concentration in control may be due to moisture stress at the time of harvesting (Fig. 1). The increase in â-carotene content was also observed by Najla et al. (2012) in parsley under moisture stress.

Nutrients and mulch treatments have also shown significant effects on vitamin-C content. The highest vitamin-C content 89.3 mg/100g was recorded from the treatment T_4 (N_{80} P_{80} K_{60}) under the no mulch condition. However, under mulching vitamin-C content was highest (70.2 mg) from the treatment T_7 (N_{80} P_{100} K_{60}) while, it was statistically at par with T_4.The decreases in the vitamin–C content was observed with the increases in the dosage of N and P. Similar findings was also observed by Slosar et al. (2016) in broccoli.

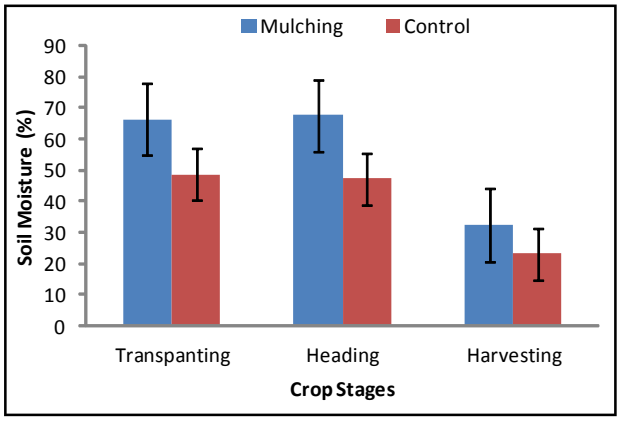

Fig. 1 Soil moisture regime at different stages of crop

Boskovic-Rakocevic et al. (2012) observed negative correlation between N and vitamin-C content and it was significantly higher under the no mulch over the mulching condition. The similar finding was also reported by Kosterna et al. 2014. The lower ascorbic acid content in broccoli under mulching could be also a result of higher soil moisture under mulch and moisture stress under the control, as it is increased with stress (Devarshi and Khanna-Chopra 2006).

Effect on soil moisture and thermal regime: The mulching has shown significant effect on the soil temperature and moisture over the control condition. The temperature of soil under mulching was higher over the control and air throughout the growing period (Fig. 2). The soil temperature under no mulch condition was in the range of maximum (20.6-26.8 ^{0}C) and minimum (11.7-15.1 ^{0}C). However, under the mulching condition the range of maximum and minimum temperature was 21.5-27.2 ^{0}C and 15.7-18.6 ^{0}C, respectively. Likewise, under mulching condition the decreases in soil temperature especially in minimum temperature was least as compare to the no mulch condition. The mulching probably acted as an insulator, resulting in smaller fluctuations in soil temperature. Further, mulching has also shown significant effect on the soil moisture and it was significantly higher over the control condition throughout the growing period (Fig.1). The highest soil moisture and temperature under mulching condition may be due to the least evaporation and minimum loss of heat from the surface soil. Mulching reduces the changes of soil temperature and decrease the gap between the Maximum and minimum hence stabilize the soil temperature.

Effect on the chemical properties of the soil: The results of the present investigation have shown the significant effects of different dosage of N and P, along with mulching on the properties of the soil (Table 4). Among the nutrients treatment combinations the

Table 4: Effect of different dosage of N, P and mulching on properties of soil

Dosage of N (kg/ha)	Dosage of P (kg/ha)							
	Un-mulch				Mulching			
	60	80	100	Mean	60	80	100	Mean
Availability of N (kg/ha)								
80	210.4^{b}	213.9^{b}	217.6^{c}	214.0^{c}	282.4^{a}	284.1^{b}	246.6^{c}	271.0^{b}
100	226.5^{ab}	226.5^{b}	222.8^{b}	225.3^{b}	276.8^{a}	288.9^{b}	326.8^{b}	297.5^{a}
120	232.2^{a}	253.4^{a}	282.3^{a}	256.0^{a}	291.2^{a}	353.9^{a}	355.7^{a}	312.0^{a}
Mean	223.0	231.3	240.9	231.7	283.5	309.0	309.7	293.7
LSD		19.17		10.77		19.17		10.77
Availability of P (kg/ha)								
80	20.1^{b}	24.2^{a}	25.5^{a}	23.3^{a}	23.6^{b}	28.2^{a}	29.6^{a}	27.1^{b}
100	23.2^{a}	24.9^{a}	25.9^{a}	24.7^{a}	25.5^{ab}	28.2^{a}	29.7^{a}	27.8^{ab}
120	20.8^{ab}	25.9^{a}	26.8^{a}	24.5^{a}	26.7^{a}	29.1^{a}	29.9^{a}	28.6^{a}
Mean	21.4	25.0	26.1	24.1	25.3	28.5	29.7	27.8
LSD		2.76		1.39		2.76		1.39
Availability of K (kg/ha)								
80	204.7^{b}	216.9^{c}	247.0^{c}	222.9^{c}	290.3^{c}	296.7^{c}	306.6^{a}	297.9^{c}
100	206.6^{b}	247.7^{a}	274.0^{a}	242.8^{a}	296.6^{b}	301.6^{b}	306.1^{a}	301.4^{b}
120	214.1^{a}	221.4^{b}	256.6^{b}	230.7^{b}	306.6^{a}	306.1^{a}	309.2^{a}	307.3^{a}
Mean	208.5	228.7	259.2	232.1	297.8	301.5	307.3	302.2
LSD		5.36		4.33		5.36		4.33
Soil Organic Carbon (SOC, %)								
80	2.21^{a}	2.30^{a}	2.12^{b}	2.25^{a}	2.28^{b}	2.06^{b}	2.36^{a}	2.23^{b}
100	2.00^{b}	2.35^{a}	2.36^{a}	2.35^{a}	2.45^{a}	2.37^{a}	2.40^{a}	2.41^{a}
120	2.34^{a}	2.43^{a}	2.45^{a}	2.25^{a}	2.60^{a}	2.40^{a}	2.40^{a}	2.47^{a}
Mean	2.18	2.36	2.31	2.28	2.44	2.28	2.39	2.37
LSD		0.19		0.12		0.19		0.12
Soil pH (%)								
80	4.19^{c}	4.41^{a}	4.45^{a}	4.35^{b}	4.51^{a}	4.45^{b}	4.45^{b}	4.47^{b}
100	4.38^{b}	4.44^{a}	4.51^{a}	4.44^{ab}	4.50^{a}	4.62^{a}	4.61^{a}	4.57^{a}
120	4.45^{a}	4.46^{a}	4.50^{a}	4.47^{a}	4.48^{a}	4.57^{ab}	4.62^{a}	4.56^{a}
Mean	4.34	4.44	4.49	4.42	4.50	4.55	4.56	4.53
LSD		0.12		0.09		0.12		0.09

* Means with the same letter in column are not significantly different at P<0.05

available N was higher under the mulch condition over the no mulch conditions. The higher availability of N and P under the mulch condition over the no mulch may be due to the reason that mulching reduces the N loss as well as decomposition of mulch (residues) produces organic acids which may reduces the fixation of P and increases the availability. Increase in availability of N and P was also observed by Dong et al. (2012) with the application of NPK and organic manure. The availability of K was also influenced by the varying dosage of N and P under both mulch and un-mulch conditions. The significant improvement in K under the mulch condition over the no mulch may be due decomposition and release of some K from the paddy straw (mulch) which is rich in K and as well as reduces the leaching loss from the soil. Li et al. (2006) observed significant increase in available of K with the application of paddy straw. Dong et al. (2012) also observed higher availability of K with the application of NPK and organic manure. Among the different combination of N and P, it was observed that N_{120} and P_{100} is the treatments where we got the maximum available N, P as well as K. The improvement in soil organic carbon (SOC) was also observed with the mulch and different combinations of N and P. The SOC was increases with the increases in the dosage of N. However, the effect of P on availability of SOC was non-significant. Dong et al. (2012) also observed the significant improvement in SOC with the application of organic manure and NPK. The soil of this region is acidic in nature and it was observed that, pH of the soil was slightly higher under the mulching over the un-mulch conditions (Table 4). This may be due to increases in the SOC and exchangeable cation as well reduction in leaching. Lutaladio et al. (1992) also observed as increases in the soil pH with the addition of organic mulch continuously in cassava grown under acid soil. The findings indicate that mulching has a significant effect on growth and yield attributing traits

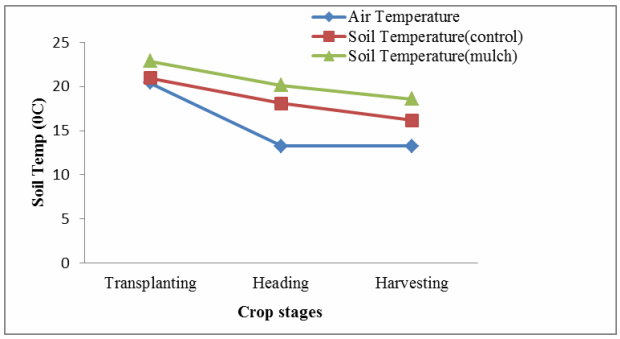

Fig. 2 Temperature regime at different stages of crop

and which led to increase in yield. Mulching is also effective to improve the quality traits such as protein and sugar, however vitamin-C and â-carotene were higher under the control and this may be due to response of moisture stress (Njala et al. 2012) at the time of harvesting (Fig. 1). Mulching also has a significant effect on the improvement in soil fertility by increasing the available NPK and improvement in SOC and pH by decomposition, mineralization (Lutaladio et al. 1992) and also by protecting the losses of soil nutrients by leaching and fixation. The increase in dosage of N and P has shown significant increase in soil fertility, yield attributing traits and nutritional values (total sugar, protein and â-carotene) under both mulch and no-mulch conditions. Vitamin-C content in head has decrease with increase in the dosage of N and this may be due to negative effect of N (Xu et al. 2010 and Slosar et al. 2016). From the above results of the experiment it can be concluded that, treatment combination comprises of mulch (10 t/ha) + FYM (10 t/ha) + N_{120} P_{80} K_{60} could be utilized by the famers for the higher yield (18.4%) in mid-hills and acidic soil condition without impairing soil fertility.

सारांश

मिट्टी के स्वास्थ्य और ब्रोकली की पौध का विकास, उपज और गुणवत्ता पर पलवार तथा नत्रजन और फास्फोरस के अलग–अलग मात्रा के प्रभाव का अध्ययन करने के लिय रबी मौसम में लगातार तीन वर्षों (2013–14 से 2015–16) के दौरान, मेघालय के मध्य पहाड़ी में संकर किस्म 'पुष्पा' को समाहित कर किया गया। कुल नौ उपचारों में नत्रजन (यूरिया) और फास्फोरस (एसएसपी) की अलग–अलग मात्रा वाले पाषेक तत्व के संकलन को पलवार के साथ और बिना पलवार के किया गया। यह प्रयोग रैण्डोमाइज्ड ब्लॉक डिजाइन में तीन प्रतिकृतियों के साथ किया गया। मिट्टी के भौतिक और रासायनिक गुणों, पौधों का विकास, उपज और गुणवत्ता की विशेषताओं का पर्यवेक्षण और आंकड़ों का विश्लेषण किया गया। पलवार के परिणाम स्वरूप मिट्टी की उर्वरता के मापदंडों के साथ–साथ ब्रोकली के उपज और गुणवत्ता में महत्वपूर्ण सुधार पाया गया। नत्रजन और फास्फोरस की मात्रा में वृद्धि के साथ पलवार की परिस्थिति के तहत विटामिन–सी और बीटा कैरोटीन को छोड़कर सभी विकास, उपज और गुणवत्ता वाले लक्षणों में वृद्धि हुयी। उपचार में घास का पलवार (10 टन/हेक्टेयर) + कम्पोस्ट की खाद (10 टन/हेक्टेयर) + नत्रजन 120 किग्रा./हे., फास्फोरस 80 किग्रा./हे. और पोटैशियत 60 किग्रा/हे. के प्रयोग से पौधे के वजन (0.80 किलोग्राम), बाजारयोग्य वजन (0.41 किग्रा.) और उपज (16.6 टन/हेक्टेयर) में वषद्धि पायी गयी जो अन्य उपचार की तुलना में 18.4 प्रतिशत अधिक थी और इस परिणाम का उपयोग किसान अपनी आमदनी की वृद्धि के लिए कर सकते हैं।

References

Babik I and Elkner K (2002) The effect of nitrogen fertilization and irrigation on yield and quality of broccoli. Acta Hort 571: 33-43.

Belec C, Villeneuve S, Coulombe J and Tremblay N (2001) Influence of nitrogen fertilization on yield, hollow stem incidence and sap nitrate concentration in broccoli. Can J Plant Sci 81: 765–772.

Beverly RB, Jarrell WM and Letey JJ (1986) A nitrogen and water response surface for sprinkler-irrigated broccoli. Agron J 78: 91-94.

Boskovic-Rakocevic L, Pavlovic R, Zdravkovic J, Zdravkovic M, Pavlovic N and Djuric M (2012) Effect of nitrogen fertilization on carrot quality. African J Agric Res 7(18): 2884-2900.

Chenard CH, Kopsell DA and Kopsell DE (2005). Nitrogen concentration affects nutrient and carotenoid accumulation in Parsley. J Plant Nutr 28(2): 285-297.

Devarshi S and Khanna-Chopra R (2006) Drought acclimation confers oxidative stress tolerance by inducing co-ordinated antioxidant defense at cellular and subcellular level in leaves of wheat seedlings. Physiol Plant 127:494–506.

Dong W, Zhang X, Wang H, Dai X, Sun X, Qiu W and Yang F (2012) Effect of different fertilizer application on the soil fertility of paddy soils in red soil region of Southern China. PLoS ONE, 7(9), e44504. http://doi.org/10.1371/journal.pone.0044504.

Franczuk J, Jablonska-Ceglarek R, Zeniewicz-Bajkowaka A, Kosterna E and Rosa R (2009) The effect of plant mulches on the nutritive value of red cabbage and onion. Veg Crop Res Bull 70: 125-134.

Gastal F and Lemaire G (2002) N uptake and distribution in crops: an agronomical and ecophysiological perspective. J Exp Bot 53(370): 789-99.

Ghurbat HM, Taha ZS and Jiyan AT (2016) Effect of mulching and organic fertilizer on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica*). J Zan Sulai 18(1): 207-2012.

Jasim AH, Al-Timmen WMA (2014) The effect of mulch and fertilizers on broccoli (*Brassica oleracea* L. var. *italica*) oxidants and antioxidants. Net J Agri Sci 2(4): 124-130.

Katiyar D, Tripathi SM, Dwivedi AK and Pandey V (2012) Effect of nitrogen and phosphorous on crop growth, head yield and quality of broccoli (*Brassica oleracea* L. var. *italica*). Hortflora Res Spectrum 1(2): 172-174.

Kirnak H and Demirtas MN (2006) Effects of different irrigation regimes and mulches on yield and macronutrition levels of

drip-irrigated cucumber under open field conditions. J Plant Nutr 29: 1675-1690.

Kosterna E (2014) Soil mulching with straw in broccoli cultivation for early harvest. J Ecol Eng 15(2)100-107.

Kumar P and Sharma SK (2001) Performance of different sprouting broccoli (*Brassica oleracea* var. *italica*) cultivars under different combinations of nitrogen, phosphorus and potassium. Indian J Agri Sci 71(8): 558-600.

Lea PJ and Azevedo RA (2006) Nitrogen use efficiency 1- Uptake of nitrogen from the soil. Ann Appl Biol 149: 243–247.

Li Z, Zhang T and Chen B (2006) Changes in organic carbon and nutrient contents of highly productive paddy soils in Yujiang county of Jiangxi province, China and their environmental application. Agri Sci China 5: 522–529.

Lopez-Berenguer C, Carvajal M, Garcea-Viguera C and Alcaraz CF (2007) Nitrogen, phosphorus, and sulfur nutrition in broccoli plants grown under salinity. J Plant Nutr 30: 1855–1870.

Lutaladio NB, Wahua TAT and Hahn SK (1992) Effects of mulch on soil properties and on the performance of late season cassava (*Manihot esculenta* Crantz.) on an acid ultisol in South Western Zaire. Tropicultura 10(1): 20-16.

Najla S, Sanoubar R and Murshed R (2012) Morphological and biochemical changes in two parsley varieties upon water stress. Physiol Mol Biol Plants 18(2): 133–139.

Neethu TM, Tripathi SM, Narwade AV and Sreeganesh S (2015) Effect of N and P levels on growth and yield parameters of broccoli (*Brassica oleracea* L. var. *italica*) under South Gujrat soil conditions. Int J Trop Agric 33(2): 913-917.

Rangana S (1977) Manuals of Analysis of Fruit and Vegetable Products. Tata Mc Graw Hill Publishing Co Ltd., New Delhi.

Singh BK, Pathak KA, Ramakrishna Y, Verma VK and Deka BC (2013) Vermicompost, mulching and irrigation level on growth, yield and TSS of tomato. Indian J Hill Farm 26 (2): 105-110.

Slosar M, Uher A, Andrejiova A and Jurikova T (2016) Selected yield and qualitative parameters of broccoli in dependence on nitrogen, sulfur, and zinc fertilization. Turkish J Agric For 40: 465-473.

Xu CJ, Guo RF, Yan HZ, Yuan J, Sun B, Yuan GF and Wang QM (2010) Effect of nitrogen fertilization on ascorbic acid, glucoraphanin content and quinone reductase activity in broccoli floret and stem. J Food Agric Environ 8(1): 179-184.