Impact of mulch, spacing and fertiliser on growth, yield and economics of broccoli (Brassica oleracea L. Var. Italica) under crop cafeteria in Narsinghpur district M.P

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Abstract

A two year field experiment was conducted to examine the impact of mulch, fertiliser and spacing on growth, yield and economics of broccoli (Brassica oleracea L. var. Italica) under crop cafeteria in Narsinghpur District M.P. Performance of broccoli was evaluated under Effect of Spacing S1(45x30cm) S2(45x40cm) S3(45x50cm), effect of organic manure F0 (No manure) F1 (FYM) F2 (vermi-compost) and effect of mulch M0 (no mulch) M1 (silver black polythene) M2 (paddy straw) was applied. Experiment was performed with three replications with completely randomized design (RBD). The use of M2 paddy straw mulch S3(45x50 cm) spacing and F2 Vermi-compost showed the superior results as compared to all other treatments. The maximum marketable yield 21.32 Kg and total Yield 27.03 Kg was recorded from paddy straw mulch while the minimum marketable yield 14.18 Kg and total yield 18.66 Kg was recorded from mulch condition. Where the maximum marketable yield 24.06 Kg and total Yield 30.07 Kg was recorded from S3 while the minimum marketable 18.30 Kg and total yield 23.76 Kg was recorded from S1 plant spacing. Maximum marketable yield 26.04 Kg and total Yield 32.17 Kg was recorded from F3 while the minimum 11.68 Kg and total yield 15.55 Kg was recorded from F0.

Keywords: Plant spacing, organic manure, mulching, broccoli, yield

Introduction

Broccoli, botanically known as Brassica oleracea L. var. Italica, is native to the Mediterranean. Broccoli has been considered a very valuable food by the Italians since the Roman Empire, but when first introduced in England in the mid-18th century, broccoli was referred to as “Italian asparagus. "Brocoli (Brassica oleracea var. Italica) is an herbaceous winter vegetable and commercial cultivated in India. There are two different forms of broccoli: sprouting broccoli, and heading broccoli. (Dhillon et al. 2005) stated that broccoli is one of the most important and popular vegetable crops in many countries of the world because of its good organoleptic properties and high nutritive value. Heading broccoli is the form most commonly grown in India. The curd of broccoli is formed from a compact flower head and produces a green curd that rapidly develops into a mass of fertile flower buds stated by Biggs, T. (1993). In India, its cultivation is negligible but now it is becoming increasingly popular in metro city. It prefers cool moist climate for quality heads. Broccoli has high nutritive value and many health benefits. The American Cancer Society (ACS) indicated that it has several anti-carcinogenic effects. It is a good source of vitamin A, calcium and Vitamin B2 and minerals especially of potassium, phosphorus, sulphur and magnesium and micro elements (Aboul-Nasr et al. 2000 and Sander D.C.1996). It also contains flavonoids, phenolic acids and soluble dietary fiber, disaccharides, beta carotene and amino acids (including a high content of lysine) too and it has antioxidant and anticancer activity (Podsędek, A., 2007). Broccoli soup is a delicacy in big hotels and resorts which is more nutritious than other coles, such as cabbage, cauliflower. Proper spacing, organic manure and mulch for production of broccoli are basic requirements for obtaining maximum yield and high return of broccoli (Salaria A. S. and Salaria B. S., 2011). Unless the broccoli plant grows inappropriate weather conditions, it will not change from a vegetative to a reproductive phase, and thus it will not produce head. Higher plant population reduced head size, lower average...
Materials and Methods

Site and soil description

The field experiment was carried out during two successive growth seasons of 2016 and 2017, at Krishi Vigyan Kendra Narsinghpur, JNKVV, Jabalpur M.P. The site was located at between North latitude 22° 36' and 23° 16' and east longitude 78° 27' and 79° 40'. The climate of the study area is subtropical with normal annual rainfall of Narsinghpur district is 1217.6 mm. District received maximum rainfall during south west monsoon period i.e. June to September. About 91.3% of the annual rainfall received during monsoon season. Only 8.7% of the annual rainfall takes place between October to May period. The average wind speed in the area is 4.2 km/h. Physical properties of soils in the experimental plots were determined for 0-30cm depth. The soils are usually clay to loamy in texture with calcareous concretions invariably present They are sticky and in summers, due to shrinkage, develop deep cracks. The soils predominantly consist of montmorillonite type of clay minerals.

Experimental treatments and design

The present investigation was executed at Crop cafeteria, Krishi Vigyan Kendra Narsinghpur, JNKVV, University, Jabalpur M.P. 2016-17. The experiment was laid out in a Randomized Block Design with three replications. The experiment was carried out with three different plant spacing (S1- 45 cm × 30 cm, S2- 45 cm × 40 cm and S3- 45 cm × 50 cm). B Organic manure (No, FYM, Vermi compost) and effect of Mulch M0 (No Mulch), M1(Silver black poly mulch), M2(Paddy straw). To raise the crop recommended package of practices was followed. The date of seed sowing in nursery bed was on 20th October 2016 and date of transplanting on 25th November 2016 during Rabi season. Data recorded on plant height (at 20DAT, 40DAT, at harvest), number of leaves (at 20DAT, 40DAT, at harvest), days taken for curd initiation, days taken for harvesting, number of curd per plant, curd diameter, weight of primary curd, weight of secondary curd, marketable yield, unmarketable yield and total yield.

Results and Discussion

Effect of Mulch

Application of mulching had showed significant influence on the height of broccoli plants at 20, 40DAT and maturity (Figure 1). At 20 DAT, the highest plant height (21.21 cm) was measured from M2 that was statistically similar to that of M1 while the lowest height (20.32 cm) was recorded from M0. At 40 DAT, the highest plant height (34.76 cm) was measured from M2 that was statistically similar to that of M1 while the lowest height (31.23 cm) was recorded from M0. At maturity, the highest plant height (51.56 cm) was measured from M2 and the lowest height (49.20 cm) was recorded from M0 treatment. It was revealed that the plot covered by paddy straw mulching gave better plant height then control. This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). Similar result was found by Rahman et al. 1989 [9] on growth of cabbage. Application of mulching was significantly influenced on the number of leaves of broccoli plants at 20, 40DAT and maturity (Figure 1). At 20 DAT, the maximum numbers of leaves (11.67) were found in M1 that was statistically similar to that of M0 while the minimum (10.23) were found in M0. At 40 DAT the maximum numbers of leaves (15.89) were observed from M2 that was statistically similar to that of M1 while the minimum (13.45) were found in M0. At maturity, the maximum numbers of leaves (20.34) were observed from M2 which was statistically similar to M1 while the minimum (18.67) were found in M0.

Effect of plant spacing

The more plant spacing showed most effective in comparison to less plant spacing. At 20 DAT highest height of the plant was achieved as (21.33 cm) in S1(45 X 50 cm) spacing followed by S2(20.90 cm) and lowest (20.32 cm) plant height was noticed in plant spacing S3(45 X 30 cm). At 40 DAT, highest height of the plant was achieved as (38.45 cm) in 45 X 50 cm spacing followed by 45 X 40 (35.23 cm) and lowest 34.22 cm plant height was noticed in plant spacing 45 X 30 cm. At maturity, highest height of the plant was achieved as (56.34 cm) in 45 X 50 cm spacing followed by 45 X 40 (55.12 cm) and lowest (54.23 cm) plant height was noticed in plant spacing 45 X 30 cm. In case of number of leaves at 20DAT also 45 X 50 cm plant spacing was found most effective with maximum number of leaves 15.78 and followed by 14.34 respective plant spacing 45x40 cm99m while minimum 12.23 were found in 45x 30 cm.At 40 DAT, maximum number of leaves was achieved as (19.45) in 45 X 50 cm spacing followed by 45 X 40cm (18.56) and lowest (16.39) maximum number of leaves was noticed in plant spacing
spacing 45 X 30 cm. At maturity, highest height of the plant was achieved as 24.78 cm in 45 X 50 cm spacing followed by 45 X 40 (23.99 cm) and 21.46 cm minimum number of leaves was noticed in plant spacing 45 X 30 cm.

**Effect of Organic Manure**

Application of organic manure had showed significant influence on the height of broccoli plants (Figure 1). At 20 DAT, the highest plant height (21.52 cm) F1 followed by (20.23 cm) F0 and lowest (19.91 cm) plant height was noticed in F0. At 40 DAT, the highest plant height (37.66 cm) F2 followed by (35.50 cm) F1 and lowest (33.34 cm) plant height was noticed in F0.At maturity, highest height of the plant was achieved as 56.34 cm in F2 followed by (55.34 cm) in F1 and lowest plant height was achieved (54.41 cm) in F0.

Application of manure was significantly influenced on the number of leaves of broccoli plants at 20, 40 DAT and maturity (Figure 1). At 20 DAT, the maximum numbers of leaves (13.99) were found in F2 that was statistically similar to that of F1(13.79) while the minimum (9.89) were found in F0. At 40 DAT the maximum numbers of leaves (18.12) were observed from F2 that was statistically similar to that of F1(17.34) while the minimum (14.67) were found in F0. At maturity, the maximum numbers of leaves (23.26) were observed from F2 which was statistically similar to F1 (22.21) while the minimum (19.99) were found in F0.

**Yield parameters**

The application of mulching significantly influenced the number of days required for curd initiation (Table 2). The minimum days (65.96) required for 80% curd initiation were observed from M1 which was statistically similar to that of M0 and the maximum (68.12) days were required by M0. Application of mulching significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (85.45) from M1 which was statistically similar to that of M2(86.67) and the maximum (89.21) days were required by M0. This results revealed that the No. of Curd per plant increase with mulching application. The maximum no. of curd per plant observed (13.32) from M2 which was statistically similar to that of M1(12.11) and the minimum (10.01) days were required by M0. This result was revealed that the curd diameter increased with mulching application. This might be caused that mulching increase soil moisture that helps in water uptake by the plants. Similar trend of the result was found by Islam et al. (2014) [5]. Maximum curd diameter was observed from 15.52cm was observed from M2 and minimum curd diameter(12.25cm) found from M0 unmulch condition. Mulching showed a significant influence on weight of primary curd of broccoli plants (Table 2). The maximum primary curd weight (379.23 g) was measured from M2 which was statistically similar to that of M1(322.45 g) while the minimum weight of primary curd (290.23 g) was recorded from M0. It was observed number of secondary curd increased with mulching application. Application of mulching exhibited a significant influence on weight of secondary curd of broccoli plants (Table 2). The maximum secondary curd weight (87.21 g) was recorded from M2 which was statistically similar to that of M1 (75.10 g) while the minimum (60.11 g) was recorded from M0. It was observed marketable and total yield per plot increased with mulching application. Application of mulching exhibited a significant influence on marketable and total yield of broccoli plants (Table 2). The maximum marketable yield (21.32Kg) and total Yield (27.03 Kg) was recorded from M2 which was statistically similar to that of M1 (18.28Kg) and total yield (23.77 Kg) while the minimum (14.18 Kg) and total yield (18.66 Kg) was recorded from M0.

The more plant spacing showed most effective in comparison to less plant spacing influenced the number of days required for curd initiation (Table 2). The minimum days (58.87) required for curd initiation were observed from S1(45x50) which was statistically similar (60.23) to that of S2(45x40) and the maximum (60.78) days were required by S1(45x30). Spacing significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (79.56) from S1(45x50) which was statistically similar to that of S2(45x40) (81.56) and the maximum (82.23) days were required by S1(45x30). The maximum no. of curd per plant observed (16.23) from S1(45x30) which was statistically similar to that of S2(45x40)(15.56) and the minimum (15.33) days were required by S1(45x50). This result was revealed that the curd diameter increased with plant spacing (Table 2). The maximum primary curd diameter (20.67 cm) was measured from S1(45x50) which was statistically similar to that of S2(45x40) (20.22 cm) while the minimum curd diameter (19.39cm ) from S1(45x30). The maximum primary curd weight (638.45g) was measured from S1(45x30) which was statistically similar to that of S2(45x40) (602.34g) while the minimum weight of primary curd (590.22 g) was recorded from S1(45x50). The maximum secondary curd weight (90.23g) was measured from S1(45x50) which was statistically similar to that of S2(45x40) (87.34g) while the minimum weight of secondary curd (81.78 g) was recorded from S1(45x30). The maximum marketable yield (24.06 Kg) and total Yield (30.07Kg) was recorded from S1(45x30) which was statistically similar to that of S2(45x40) (21.35Kg) and total yield (27.03Kg) while the minimum (18.30 Kg) and total yield (23.76 Kg) was recorded from S1. 45cm x 30cm plant spacing produced the highest main head yield and 45cm x 50cm plant spacing produced the lowest main head yield. Similar results have reported by (Roy et. al. 1990)[10].

The application of manure significantly influenced the number of days required for curd initiation (Table 2). The minimum days (59.55) required were observed from F2 which was statistically similar to that of F1(61.46) and the maximum (67.25) days were required by F0. Application of manuring significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (81.22) from F2 which was statistically similar to that of F1(82.56) and the maximum (88.34) days were required by F0. This results revealed that the No. of Curd per plant increase with manuring application. The maximum no. of curd per plant observed (14.89) from F2 which was statistically similar to that of F1(12.34) and the minimum (9.78) days were required by F0. This result was revealed that the curd diameter increased with manure application. This might be caused that manure increase soil moisture that helps in water uptake by the plants. The maximum curd diameter observed (19.45 cm) from F2 which was statistically similar to that of F1(18.88 cm) and the minimum (11.89 cm) days were required by F0. The maximum primary curd weight (645.77 g) was measured from F2 which was statistically similar to that of F1(567.23 g) while the minimum weight of primary curd (285.23 g) was recorded from F0. It was observed number of secondary curd increased with manuring. Application of manure exhibited a significant influence on weight of secondary curd of broccoli plants (Table 2). The maximum secondary curd weight (84.34 g) was recorded from F2 which was statistically similar to that of F1(71.45 g) while the minimum (60.89 g) was recorded from F0.
It was observed that the number of marketable and total yield per plot increased with manure application. Application of mulching exhibited a significant influence on marketable and total yield of broccoli plants (Table 2). The maximum marketable yield (26.04 Kg) and total yield (32.17 Kg) was recorded from F2 which was statistically similar to that of F1 (14.15 Kg) and total yield (18.62 Kg) while the minimum (11.68 Kg) and total yield (15.52 Kg) was recorded from F0.

**Table 1**: Effect of different treatment on Plant growth parameters at the time of 20DAT, 40DAT and harvesting

| Treatment | Plant Height (cm) | No. of leaves |
|-----------|-------------------|---------------|
|           | 20DAT | 40DAT | Harvesting | 20DAT | 40DAT | Harvesting |
| **Mulch** |         |       |           |        |       |           |
| M₀        | 20.32  | 31.23 | 49.24     | 10.23  | 13.45 | 18.67     |
| M₁        | 20.52  | 32.48 | 50.23     | 10.55  | 15.55 | 19.89     |
| M₂        | 21.21  | 34.76 | 51.56     | 11.67  | 15.89 | 20.34     |
| Mean      | 20.75  | 32.99 | 50.4      | 10.95  | 14.67 | 19.28     |
| SE        | 0.272845 | 1.03382 | 0.672119 | 0.436552 | 0.763006 | 0.498877 |
| CV        | 2.277502 | 5.424669 | 2.309811 | 6.905301 | 9.008621 | 4.48174 |
| **Spacing** |         |       |           |        |       |           |
| S₁(45x30) | 20.32  | 34.22 | 54.23     | 12.23  | 16.39 | 21.46     |
| S₂(45x40) | 20.90  | 35.23 | 55.12     | 14.34  | 18.56 | 23.99     |
| S₃(45x50) | 21.33  | 38.45 | 56.34     | 15.78  | 19.45 | 24.78     |
| Mean      | 20.8   | 36.335| 55.285    | 14.005 | 17.475 | 22.725    |
| SE        | 0.290593 | 1.275439 | 0.611853 | 1.030863 | 0.908741 | 1.001316 |
| CV        | 2.419819 | 6.079882 | 1.916057 | 12.74906 | 9.007076 | 7.631814 |
| **Manure** |         |       |           |        |       |           |
| No        | 19.91  | 33.34 | 54.44     | 9.89   | 14.67 | 19.99     |
| FYM       | 20.23  | 35.5  | 55.34     | 13.79  | 17.34 | 22.21     |
| Vermicompost | 21.52  | 37.66 | 56.34     | 13.99  | 18.12 | 23.26     |
| Mean      | 20.71  | 35.5  | 55.39     | 11.94  | 16.395 | 21.625    |
| SE        | 0.492082 | 1.247077 | 0.548736 | 1.334583 | 1.044557 | 0.963898 |
| CV        | 4.114461 | 6.084507 | 1.715903 | 19.35984 | 11.03523 | 7.720328 |
Table 2: Effect of different treatment with respect to days taken for Curd initiation, days taken for harvesting, Number of curd per plant, Curd diameter, weight of primary curd, weight of secondary curd, marketable yield, unmarketable yield and total yield

| Treatment | Days for Curd initiation | Days taken to first harvest | No. of Curd per plant | Diameter of primary Curd | Weight of primary curd (g) | Weight of Secondary Curd (g) | Marketable yield | Un Marketable yield | Total yield |
|-----------|--------------------------|----------------------------|-----------------------|-------------------------|---------------------------|-----------------------------|-------------------|-------------------|------------|
| Mulch     |                          |                            |                       |                         |                           |                             |                   |                   |            |
| Mo        | 68.12                    | 89.21                      | 10.01                 | 12.25                   | 290.23                    | 60.11                       | 14.18             | 4.48              | 18.66      |
| M1        | 66.23                    | 85.45                      | 12.11                 | 13.91                   | 322.45                    | 75.10                       | 18.28             | 5.49              | 23.77      |
| M2        | 65.96                    | 86.67                      | 15.52                 | 15.52                   | 379.23                    | 87.21                       | 21.32             | 5.71              | 27.03      |
| Mean      | 67.04                    | 87.94                      | 11.66                 | 13.88                   | 334.73                    | 73.66                       | 17.75             | 5.095             | 22.845     |
| SE        | 0.679485                 | 1.10749                    | 0.96696               | 0.944004                | 26.01612                  | 7.837808                    | 2.068698          | 0.378697          | 2.435805   |
| CV        | 1.755523                 | 2.181292                   | 14.35768              | 11.77576                | 13.46197                  | 18.42992                    | 20.18642          | 12.87383          | 18.46766   |
| Spacing   |                          |                            |                       |                         |                           |                             |                   |                   |            |
| S0(45x30 cm) | 60.78                  | 82.23                      | 16.23                 | 19.39                   | 638.45                    | 87.34                       | 24.06             | 6.01              | 30.07      |
| S1(45x40cm)    | 60.23                   | 81.56                      | 15.56                 | 20.22                   | 602.34                    | 81.78                       | 21.35             | 5.68              | 27.03      |
| S2(45x50cm)    | 58.87                   | 79.56                      | 15.33                 | 20.67                   | 590.22                    | 90.23                       | 18.30             | 5.46              | 23.76      |
| Mean      | 59.825                   | 80.895                     | 15.78                 | 20.03                   | 614.335                   | 88.785                      | 21.18             | 5.735             | 26.915     |
| SE        | 0.567656                 | 0.802004                   | 0.269959              | 0.374893                | 14.48555                  | 2.479563                    | 1.663734          | 0.159826          | 1.821943   |
| CV        | 1.643475                 | 1.71718                    | 2.963133              | 3.241802                | 4.084043                  | 4.837224                    | 13.60563          | 4.826979          | 11.72468   |
| Manure    |                          |                            |                       |                         |                           |                             |                   |                   |            |
| No        | 67.25                    | 88.34                      | 9.78                  | 11.89                   | 285.23                    | 60.89                       | 11.68             | 3.90              | 15.55      |
| FYM       | 61.46                    | 82.56                      | 12.34                 | 18.88                   | 567.23                    | 71.45                       | 14.15             | 4.47              | 18.62      |
| Vermicompost | 59.55                  | 81.22                      | 14.89                 | 19.45                   | 645.77                    | 84.34                       | 26.04             | 6.13              | 32.17      |
| Mean      | 63.4                     | 84.78                      | 12.335                | 15.67                   | 465.5                     | 72.615                      | 20.095            | 5.3               | 25.395     |
| SE        | 2.314954                 | 2.184521                   | 1.475131              | 2.430576                | 109.4637                  | 6.780561                    | 4.432723          | 0.668888          | 5.105834   |
| CV        | 6.324318                 | 4.462965                   | 20.71343             | 26.86587                | 40.7297                   | 16.17335                    | 38.20702          | 21.8594          | 34.82404   |

Conclusions
Impact of Mulch, Spacing and Fertilizer on growth, yield and economics of broccoli (Brassica oleracea L. var. italica) under crop cafeteria in Narsinghpur District M.P. The effect of different Mulch, Spacing and manure on the growth, yield of broccoli was evaluated. The results of the study indicated that the treatment of paddy straw mulch, maximum spacing S3 (45x50 cm) and vermicompost F2 showed the best results as compared to all other treatments. The maximum marketable yield (21.32 Kg) and total Yield (27.03 Kg) was recorded from paddy straw mulch whereas, the maximum marketable yield (24.06 Kg) and total Yield (30.07 Kg) was observed under treatment S3 (45x50) and Maximum marketable yield (26.04 Kg) and total Yield (32.17 Kg) was observed under treatment F2. Application of mulch showed significant increase in yield under spacing 45x 50 cm with vermicompost. Use of mulching, manuring and proper spacing for broccoli production can be technically viable option for the farmers of Narsinghpur district, which can give them higher yields and returns under water stress periods as compared to the present practice of keeping their fields fallow.

Experimental sites photographs at different stages
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