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Response of Faba Bean (*Vicia faba* L.) to Tillage and Crop Establishment Methods in Conjunction with Nutrient Management on Growth and Yield

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Abstract Field experiment was conducted with the objective to determine the optimum tillage and crop establishment methods and nutrient management in broad bean. The treatment comprised 4 tillage practices (conventional tillage + drilling at 30 × 15 cm spacing, conventional tillage + dibbling at 30 × 15 cm spacing, pit planting by using SRI principle at 30 × 15 cm spacing and pit planting by using SRI principle at 30 × 30 cm spacing) and 3 nutrient levels (100% RDF, 50% RDF + 50% FYM and 75% RDF + 25% FYM) which were laid out in a factorial randomized block design with 3 replications. The results showed that practicing conventional tillage with drilling at 30 × 15 cm spacing was comparable with conventional tillage + dibbling at 30 × 15 cm spacing and gave substantially greater influence on growth and yield of broad bean than other tillage practices. With respect to nutrient management, applying of 75% RDF + 25% FYM showed that significantly higher influence than other nutrient levels. Tillage practices, nutrient levels and their interactions had a positive relation in all characters of growth and yield attributes of the crop. During the early stage (20 DAS) of the crop growth it had non -significant under the study. Combination of conventional tillage + dibbling at 30 × 15 cm spacing + 75% RDF + 25% FYM gave the higher significance on growth and yield broad bean than other combinations.

Keywords Broad bean, Tillage practices, Nutrient management, Growth parameters, Yield attributes.

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Introduction

Pulses are considered as life of Indian agriculture because of their unique position in every known system of farming. Being rich in several amino acids like lycine, cysteine and arginine, they are the ideal supplement to the cereal rich diet. Coming to the *rabi* pulses, broad bean (*Vicia faba* L.) also known as faba bean and belongs to the family Fabaceae having chromosome number 2n = 24. It is an important legume crop contain a high protein compared to other legume amounting to 23% and considered as a cheap source of available protein for human food and animal consumption. It is generating a considerable household income for the farming community, improves soil fertility through biological N fixation. Increasing faba bean production is one of the major targets of the agricultural policy that target may be achieved through adoption of proper agronomic practices, among them tillage and nutrient management practices are playing a major role. Several studies have been paid regarding tillage practices and nutrient management. Moreover, tillage practices play a major role in faba bean productivity by its impact on the efficiency of nutrients absorption, improving yield attribute factors. The objective of the present study was to recognize

Table 1. Meteorological data during the experimental period (December 2016–April 2017). Max=Maximum, Min=Minimum, 700h=7AM, 1300h=1 pm, mm=millimeter, h=hours.

Mo-nth	Temp (°C) Max	Min	RH (%) 700h	1300h	Total rain-fall (mm)	Sun-shine h
Dec	23.30	8.35	92.45	52.73	0.00	5.75
Jan	22.30	6.02	82.96	42.19	10.10	6.59
Feb	24.68	8.60	86.32	41.50	35.80	6.08
Mar	24.02	11.73	83.90	52.03	66.80	6.73
Apr	20.70	15.80	96.00	82.00	32.70	2.93
Total	115	50.50	441.63	270.45	145.40	28.08
Mean	23	10.10	88.32	54.09	29.08	5.61

the suitable combination for maximizing faba bean growth, yield and its components.

Materials and Methods

Description of the study area

Field experiment was conducted during the *rabi* season of 2016-17 in the Research Farm of College of Agriculture, Central Agriculture University, Imphal. The experimental site is located at 24°81′ N latitude and 93º89′ E longitudes and at altitude of 790 m above the mean sea level which comes under the Eastern Himalayan Region (II) and the agro climatic zone Sub-Tropical Zone (NEH-4) of Manipur (Experimental Agromet Advisory Service ICAR Complex for NEH Region, Manipur Center, Lamphelphet, Imphal). The Imphal valley fall in sub-tropical climatic zone in which rainy season usually starts by second fortnight of May and it extends up to first fortnight of October. The average annual rainfall of Imphal valley is 1212 mm and the winter normally starts from the mid November and extends up to the end of February. Rainfall during winter period is traceable and uneven. Generally no extreme temperature is observed. The maximum temperature rises up to 35ºC during summer and minimum falls to 5ºC during winter. The meteorological data of Imphal valley during the crop period i.e. December to April for 2016-17 are presented in the Table 1.

Experimental materials

In the current experiment, broad bean (locally calling as Hawaimubi) seeds and 4 different tillage practices with 2 level of spacing's (30 ×15 cm and 30 × 30 cm) and 3 nutrient levels were used. The 100% recommended dose of fertilizer was 20:40:30 kg of NPK / ha and 10 tonne of FYM/ha.

Treatment and design

The treatments consisted of four (4) different tillage practices (T_1 with conventional tillage + drilling at 30 × 15 cm spacing, T_2 with conventional tillage + dibbling at 30 × 15 cm spacing, T_3 with pit planting by using SRI principle at 30 × 15 cm spacing and T_4 with pit planting by using SRI principle at 30 × 30 cm spacing and three (3) levels of nutrient (N_1 with 100% RDF, N_2 with 50% RDF + 50% FYM and N_3 with 75% RDF + 25% FYM). The experiment was laid out in Factorial randomized block design (FRBD) with three (3) replication and twelve (12) treatments.

Analysis of physico-chemical properties of soil

Initially soil samples were collected from the experimental site to access the physico-chemical properties from a depth of 0–30 cm prior to cultivation and fertilizer application. The composite soil samples were analyzed by using standard procedures for pH, EC, organic carbon, total N, available P and K to evaluate

Table 2. Physico-chemical properties of soil in the experimental site.

Physical properties: Particle size distribution (%) Sand	Silt	Clay	Textural class	Chemical properties: pH	EC (dSm^{-1})	OC (%)	Av N (kg/ha)	Av P (kg/ha)	K (kg/ha)
42.90	39.45	17.65	Loam	6.08	0.45	0.54	288.60	18.54	154.10

Table 3. Effect of tillage and crop establishment methods on growth and development of broad bean at different intervals (20, 40, 60 and 80 DAS and at harvest stage).

Tillage practices	Number of branches per plant					Plant height (cm)				
	20 DAS	40 DAS	60 DAS	80 DAS	Har-vest	20 DAS	40 DAS	60 DAS	80 DAS	Har-vest
T_1	1.91	2.54	3.49	3.49	3.49	8.96	27.04	47.76	53.76	55.29
T_2	1.77	2.31	2.88	2.88	2.88	8.92	25.39	41.93	48.35	49.49
T_3	1.57	2.22	2.61	2.61	2.61	8.78	24.51	39.72	46.92	48.29
T_4	1.42	1.91	2.13	2.13	2.13	8.74	24.17	38.77	44.62	46.23
SEm (±)	0.01	0.02	0.02	0.02	0.02	0.08	0.14	0.11	0.13	0.13
CD	NS	0.05	0.07	0.07	0.07	NS	0.42	0.34	0.39	0.40
Nutrient management										
N_1	1.43	1.98	2.43	2.43	2.43	8.69	23.67	41.42	47.71	49.15
N_2	1.65	2.20	2.76	2.76	2.76	8.89	25.27	41.98	48.12	49.46
N_3	1.93	2.56	3.14	3.14	3.14	8.97	26.89	42.73	49.41	50.87
SEm (±)	0.01	0.01	0.02	0.02	0.02	0.06	0.11	0.09	0.10	0.10
CD	NS	0.03	0.05	0.05	0.05	NS	0.31	0.25	0.29	0.30

Tillage practices	Number of leaves per plant					Total dry matter production per plant (g)				
	20 DAS	40 DAS	60 DAS	80 DAS	Har-vest	20 DAS	40 DAS	60 DAS	80 DAS	Har-vest
T_1	3.60	21.94	49.03	49.91	47.09	4.38	8.46	32.91	45.07	47.79
T_2	3.46	20.01	46.59	47.27	42.61	4.26	8.12	27.89	41.35	43.60
T_3	3.39	19.79	46.31	47.00	41.89	4.18	7.66	24.04	37.07	39.20
T_4	3.16	17.49	44.96	46.38	40.12	3.92	7.23	22.23	35.44	38.37
SEm (±)	0.02	0.09	0.09	0.18	0.17	0.04	0.06	0.09	0.13	0.12
CD	NS	0.26	0.28	0.52	0.50	NS	0.17	0.27	0.37	0.34
Nutrient management										
N_1	3.28	17.94	43.63	44.95	40.19	3.69	6.84	23.00	36.67	38.83
N_2	3.31	19.79	45.88	46.23	41.67	4.20	7.31	26.72	38.77	41.43
N_3	3.62	21.69	50.66	51.73	46.93	4.66	9.45	30.59	43.76	46.46
SEm (±)	0.01	0.07	0.07	0.13	0.13	0.03	0.04	0.07	0.10	0.09
CD	NS	0.20	0.21	0.39	0.38	NS	0.13	0.20	0.28	0.26

the initial nutrient status. After the crop harvest, the soil of each treatment was analyzed for N, P, and K status. The soil samples were air dried and ground to pass through 0.2 mm sieve for total N. Organic carbon was determined by wet digestion method as described by Walkley and Black (1934). Available N was estimated by alkaline permanganate method (Subbaiah and Asija 1956). Available P in soil was determined by Bray's method (Jackson 1973) and available K was estimated by neutral normal ammonium acetate method as described by Jackson (1973). Soil texture was analyzed by Bouyoucos hydrometer method (1962) and soil pH was measured by Buckman's zero metric pH meter (Piper 1966). EC was measured by conductometry (Jackson 1973).

Field operation

The field was cleaned, ploughed thoroughly twice by a tractor and harrowed twice to obtain a fine tilth, free from weeds. The field was then marked into 12 plots per replication. Seeds were sown in a rows at a uniform rate (drilling by 30 × 15 cm spacing), opening narrow furrow with the help of wooden stick (dibbling by 30 × 15 cm spacing) and planting was done after digging pits of the size 10 × 10 cm at a depth of 3-4 cm using 2 spacing (pit planting by 30 × 15 cm and 30 × 30 cm spacing). The source of N, P and K was Urea, SSP and MOP respectively. Harvest of the crop was carried out by leaving border rows to determine the per plot yield of broad bean.

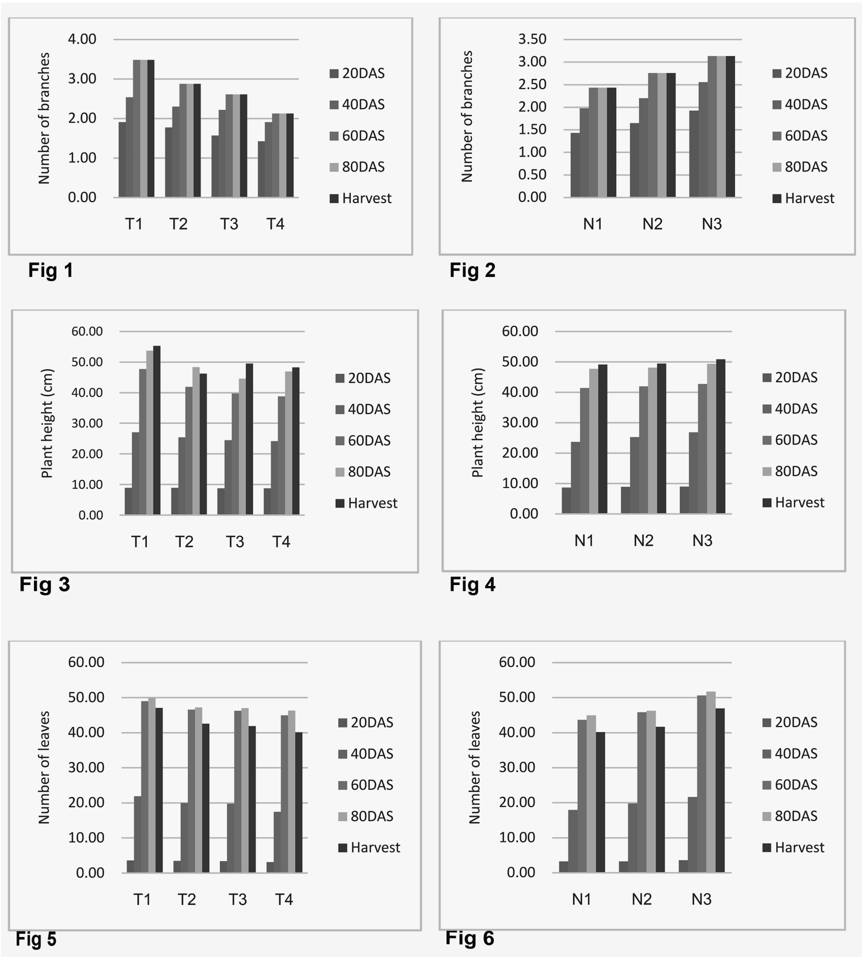


Fig. 1. Effect of tillage and crop establishment methods on branches of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 2.** Effect of nutrient management practices on number of branches of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 3.** Effect of tillage and crop establishment methods on plant height of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 4.** Effect of nutrient management practices on plant height of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 5.** Effect of tillage and crop establishment methods on number of leaves of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 6.** Effect of nutrient management practices on number of leaves of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage).

Observations recorded on crop

The observations and data on growth parameters and yield parameters of broad bean crop were recorded from 5 randomly selected and tagged representative plants from each net plot and subjected to analysis of variance using SAS 9.1 computer software. Comparisons between the treatments were made using Least Significant Difference (LSD) test at 0.05 probability levels.

Results and Discussion

Pre-sowing initial soil physico-chemical properties of the experimental soil

The pre-sowing soil analysis showed that the texture of the soil of the experimental site is dominated by the loam fractions and shown in Table 2.

Growth and development

Table 4. Effect of tillage and crop establishment methods on yield and its components of broad bean crop.

Tillage practices	Pods/ plant	Seeds/ pod	Yield parameters Seed weight/ plant (g)	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
T_1	12.00	3.45	33.98	832.11	11.21	28.81	27.93
T_2	10.78	3.08	27.09	823.33	9.51	27.93	25.34
T_3	10.42	2.94	26.12	821.11	8.95	23.24	27.80
T_4	8.66	2.99	21.20	818.89	6.92	18.78	26.92
SEm (±)	0.03	0.02	0.12	0.67	0.04	0.10	0.11
CD	0.09	0.06	0.35	1.95	0.12	0.29	0.31
Nutrient management							
N_1	9.70	3.00	23.64	820.83	8.01	22.68	26.12
N_2	10.53	3.09	27.53	824.58	9.22	24.75	27.19
N_3	11.17	3.26	30.13	826.17	10.20	26.65	27.59
SEm (±)	0.02	0.01	0.09	0.50	0.03	0.07	0.08
CD	0.07	0.04	0.26	1.46	0.09	0.21	0.23
Interaction							
T_1N_1	10.63	3.10	25.77	818.33	9.48	25.43	27.12
T_1N_2	12.03	3.40	34.51	833.33	11.27	29.73	27.51
T_1N_3	13.33	3.85	41.67	844.67	12.87	31.27	29.16
T_2N_1	10.47	3.14	26.61	818.33	8.08	26.60	23.34
T_2N_2	10.80	3.00	27.00	825.00	9.81	27.70	26.17
T_2N_3	11.07	3.09	27.65	826.67	10.64	29.50	26.51
T_3N_1	9.27	2.89	22.28	825.00	8.24	21.67	27.56
T_3N_2	10.73	2.93	27.20	823.33	8.81	22.80	27.89
T_3N_3	11.27	3.00	28.87	815.00	9.80	25.27	27.94
T_4N_1	8.43	2.87	19.89	821.67	6.25	17.03	26.85
T_4N_2	8.53	3.01	21.39	816.67	7.00	18.75	27.19
T_4N_3	9.00	3.09	22.32	818.33	7.50	20.56	26.73
SEm (±)	0.09	0.06	0.36	2.00	0.12	0.29	0.32
CD	0.27	0.17	1.05	5.85	0.36	0.86	0.93

Effect of tillage and crop establishment methods on crop growth and development

Tillage practices had a significant integral effect on resource utilization like water and nutrients, absorption of photosynthetically active radiations. Current results revealed that different tillage and crop establishment methods had significant influence on growth and development of broad bean at all the stages of the crop growth except in the early stage (20 DAS) results were shown in Table 3 and graphically represented in Figs. 1–10. According to Table 3, conventional tillage + drilling at 30 × 15 cm spacing exhibited significant effect on growth parameters and it was significantly superior over others. While, pit planting by using SRI principle at 30 × 30 cm spacing exhibited significantly lower effect on growth parameters than any other tillage practices. These results are in contrary with that obtained by Nawar and Khalil (2004) and EL-Douby and Mohamed (2002) who concluded that narrow spacing showed better performance than that of wider spacing and conventional tillage reduces the soil mechanical resistance to plant-roots penetration, leading to deeper rooting system, which increases the uptake of growth resources.

Effect of nutrient levels on crop growth and development

Current results revealed that different nutrient levels had significant influence on growth and development

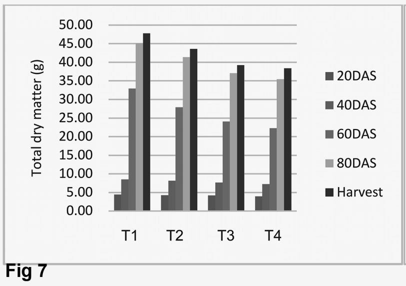
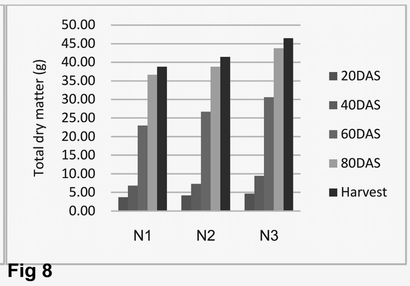


Fig 7



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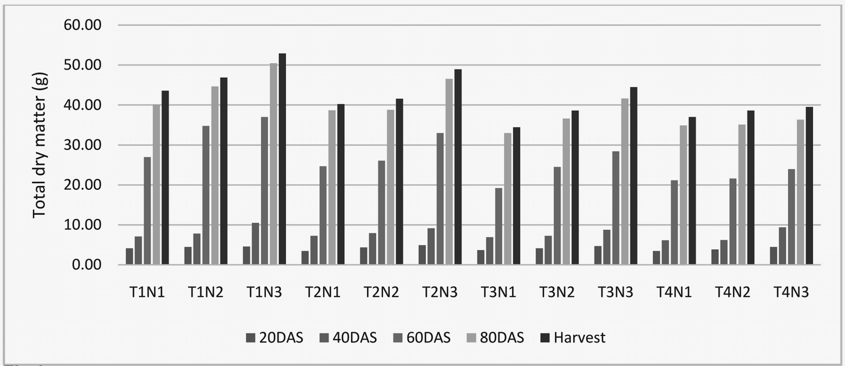

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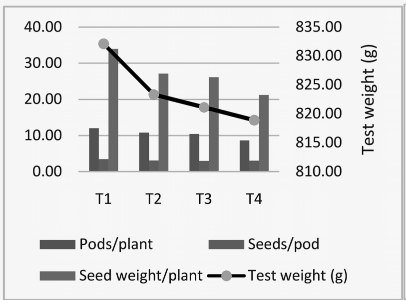

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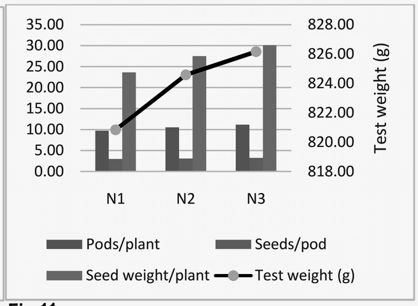

Fig 11

Fig. 7. Effect of tillage and crop establishment methods on total dry matter production of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 8.** Effect of nutrient management practices methods on total dry matter of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig. 9.** Interaction effect of tillage and crop establishment methods and nutrient management practices on total dry matter production of broad bean at different intervals (20, 40, 60 and 80 DAS and harvest stage). **Fig.10.** Effect of tillage and crop establishment methods on number of pods per plant, seeds per pod, seed weight per plant and test weight of broad bean. **Fig. 11.** Effect of nutrient management practices on number of pods per plant, seeds per pod, seed weight per plant and test weight of broad bean.

of broad bean at all the stages of the crop growth except in the early stage (20 DAS). The results were shown in Table 3 and graphically represented. According to Table 3, 75% RDF + 25% FYM had shown significant effect on broad bean crop growth and development parameters followed by 50% RDF + 50% FYM while, 100% RDF shown significantly lower influence than other nutrient levels. These results are in harmony with the results by Yirga et al. (2012) and Rouhollah et al. (2016) as they found that application of chemical fertilizers had a significant effect on growth of faba bean.

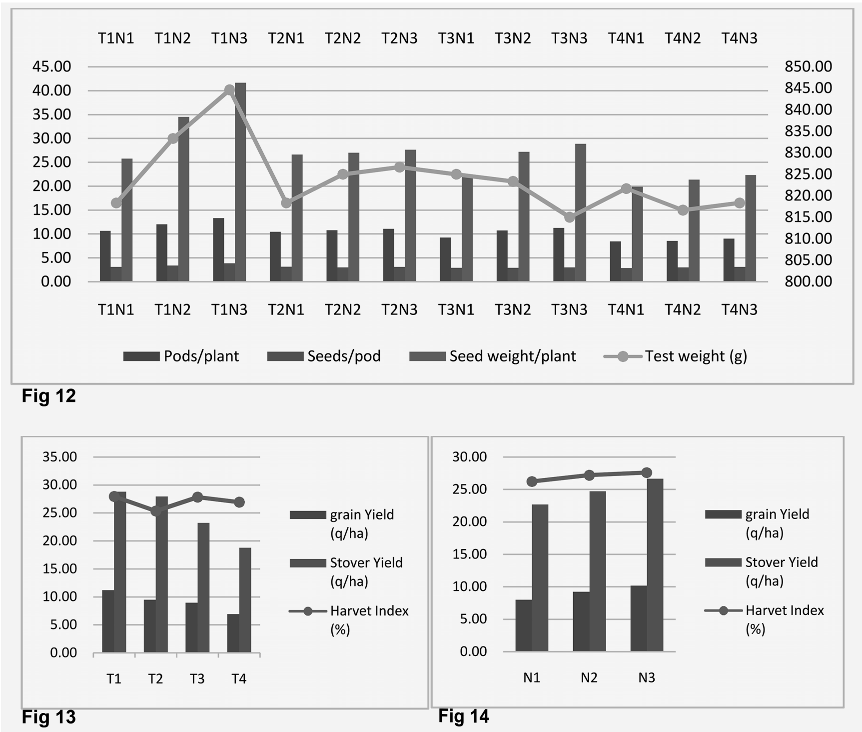

Fig. 12. Interaction effect of tillage and crop establishment methods and nutrient management practices on number of pods per plant, seeds per pod, seed weight per plant and test weight of broad bean. **Fig. 13.** Effect of tillage and crop establishment methods on grain yield, stover yield and harvest index of broad bean. **Fig. 14.** Effect of nutrient management practices on grain yield, stover yield and harvest index of broad bean.

Interaction effect tillage and crop establishment methods and nutrient management on crop growth and development

Combined effect of tillage practices and nutrient levels showed non-significant effect on all growth parameters except in Total Dry Matter (TDM) production. During the early stage of crop growth (20 DAS) combined effect had shown non-significant, while in later stages it had influenced significantly. Among the combinations conventional tillage + drilling at 30 × 15 cm spacing + 75% RDF + 25% FYM influenced significantly higher than all other combinations. While, pit planting by using SRI principle at 30 × 30 cm + 100% RDF was influenced significantly lower at 40 DAS. Mean while, conventional tillage + dibbling at 30 × 15 cm spacing + 100% RDF at 60 and 80 DAS and at harvest stage had shown lower significant influence than any other combinations.

Yield and its components

Effect of tillage and crop establishment methods on yield and its components of the crop

The data with respect to the yield parameters of broad bean crop which was influenced by different tillage and crop establishment methods is presented on Table 4 and graphically illustrated in (Figs. 11—16).

Conventional tillage + drilling at 30 × 15 cm spacing recorded higher number of yield parameters like pods / plant, seed / pod, seed weight / plant and test weight and higher seed yield, stover yield and harvest index exhibited so it was significantly superior others. While, pit planting by using SRI principle at 30 × 30 cm spacing exhibited significantly lower effect on yield parameters than any other tillage practices except in harvest index in which, conventional tillage

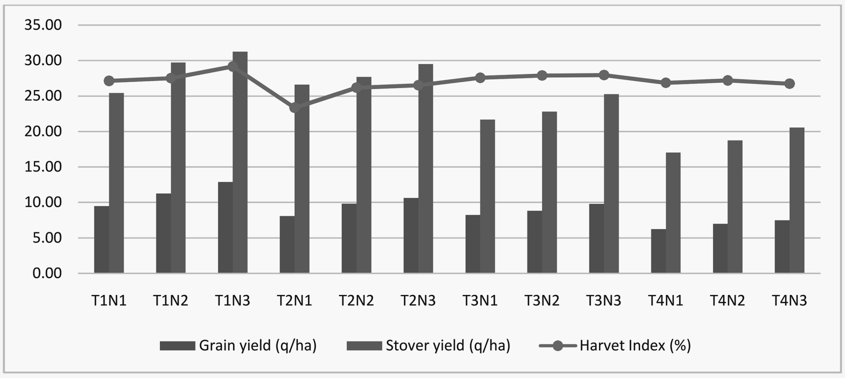

Fig 15

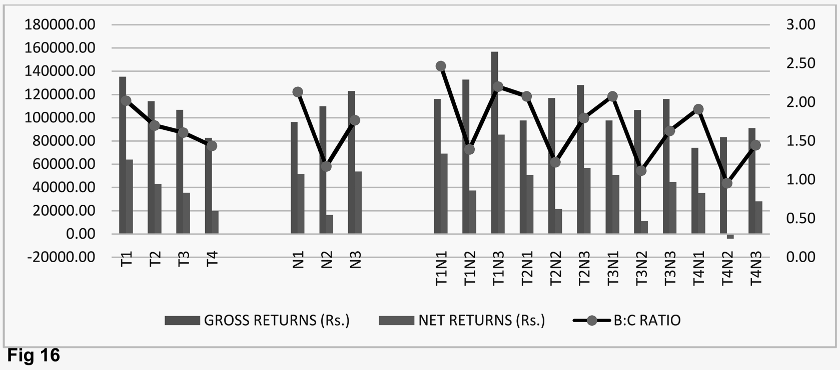

Fig 16

Fig. 15. Interaction effect of tillage and crop establishment methods and nutrient management practices on grain yield, stover yield and harvest index of broad bean. **Fig. 16.** Interaction effect of tillage and crop establishment methods and nutrient management practices on gross returns, net returns and B : C ratio of broad bean.

+ dibbling at 30 × 15 cm spacing exhibited lower significant influence. These findings are in agreement with those reported by Dahmardeh et al. (2010) who reported that conventional tillage had a positive effect on faba bean yield attributes and yield. On the other hand, similar to current findings Mahmoud (2014) reported that biomass yield was increased as plant density increased.

Effect of nutrient management on yield and its components of the crop

The result of this study indicated that combined application of FYM and chemical fertilizers positively influenced than the alone application of inorganic fertilizers. With respect to different nutrient management, 75% RDF + 25% FYM recorded substantially superior over 50% RDF + 50% FYM in terms of yield attributes and yield. However, 100% RDF recorded significantly lower influence. Similar finding have been also found by Getachew et al. (2005) who reported that the application chemical fertilizers in conjunction with FYM increasing crop yield in addition, improves the physical, chemical and biological condition.

Interaction effect of tillage and crop establishment methods and nutrient management on yield and its components of the crop

Combined effect of tillage and crop establishment and nutrient management exerted significant effect on yield and its component of faba bean which was shown in Table 4 and graphically illustrated in Figs. 12 and 15. According to Table 4, combination of conventional tillage + drilling at 30 × 15 cm spacing + 75% RDF + 25% FYM influenced significantly higher than all other combinations. While, pit planting by using SRI principle at 30 × 30 cm + 100% RDF was influenced significantly lower than any other combinations on yield and its components of broad bean except in test weight and harvest index where, the combination of pit planting by using SRI principle at 30 × 15 cm + 75% RDF + 25% FYM and conventional tillage + dibbling at 30 × 15 cm spacing + 100% RDF had shown lower significant influence respectively. Similar result were obtained by Mahmoud et al. (2014) who resported that combination of mineral-organic fertilizers along with planting density played compensating roles for the decrease of the complete mineral fertilization possibly due to direct atmospheric nitrogen fixation and / or more availability of plant nutrients due to organic fertilization.

Conclusion

Overall findings from the present investigation showed that broad bean responded well to conventional tillage with drilling method of sowing at 30 × 15 cm and balanced application of 75% RDF + 25% compost had better performance to obtain. As a result, the production of broad beans can be managed with conventional tillage with optimum level of fertilizer application, while maintaining good production levels and reducing costs.

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