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Effect of intercropping systems and fertility levels of winter maize (*Zea mays* L.) on production potential and nutrient uptake by succeeding maize crop

Parshotam Kumar Sharma, AS Bali and BC Sharma

Abstract
A field experiment was conducted to work out yield and nutrient uptake of *kharif* maize crop influenced by different winter maize based intercropping systems and fertility levels. The trial was laid out in split-plot design after the harvest of all intercropping systems in preceding maize (*Zea mays* L.) crop fertilized through organic as well as inorganic sources during the *rabi* season of 2007-08 and 2008-09. Although, Maize equivalent yield in *rabi* season was maximum in maize + peas intercropping system but significantly higher yield attributes, mean grain yield of 39.38 q ha^{-1} and stover yield of 113.51 q ha^{-1} in *kharif* maize were recorded after sole peas followed by sole maize but statistically at par with maize + peas, maize + lentil intercropping systems and sole lentil. The grain and stover yield was found significant at 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi-compost. The nutrient uptake by grain and stover of succeeding maize crop was significantly influenced by intercropping systems. Significantly higher NPK uptake was observed in sole peas which were statistically at par with sole lentil, maize + peas and maize + lentil intercropping systems. Among fertility levels, significantly higher nutrient uptake were recorded at 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi-compost as compared to 75% recommended dose. An increasing trend of N, P and K uptake was found. The gross return, net return and benefit cost ratio were also registered higher values in maize + peas intercropping system along with fertility levels of 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi-compost.

Keywords: Maize, residual effect, nutrient uptake, yield

Introduction
Maize (*Zea mays* L.) being third most important cereal crop after rice and wheat, occupies an area of 138.75 m ha producing grain yield of 577 m. t. in world (FOA,2005) [1]. In India unlike Western countries, maize is chiefly used as food for human consumption and only a small portion is used as green fodder, animal and poultry feed and industrial raw material. In Jammu and Kashmir, maize being a staple food of intermediate zone is grown approximately in 0.30 m. t. with an acreage of 0.21 m. t. in Jammu division, which have a production and productivity of 0.378 m. t. and 1.8 t ha^{-1}, respectively (Digest of statistic) [2]. Temporal and spatial intensification of cropping is the need of the day to keep the pace between food production and the burgeoning population in densely populated country like India.

Kharif maize can successfully be grown after the winter maize based intercropping systems fertilized with integrated sources of nutrient. Inclusion of legumes in the cropping system has been reported to be soil recuperative and effects the soil characteristic favorably. Consequently the preceding winter crops likely to have differential influence on the performance of succeeding *kharif* maize. Therefore, it was considered desirable to study the comparative influence of preceding winter crops on the yield and nutrient uptake of succeeding *kharif* maize. Thus, balanced fertilizer use along with organic manure like FYM and vermicompost is considered to have residual effect on the yield of succeeding crop.

Materials and Methods
A field experiment was conducted at the Research Farm of faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatta, Jammu during *rabi* 2007-08 and 2008-09 and *kharif* 2008 and 2009 on the fixed site. The soil was loamy in texture having 7.76 pH, low organic carbon (0.35%), electrical conductivity in the safe range (0.15 dS/m), low available nitrogen (223.0 Kg ha-1) and medium available phosphorus (9.45 Kg ha-1) and potassium (176.2 Kg ha-1).

The experiment with five intercropping systems in *rabi* season *viz*.T_1: maize (sole), T_2:peas (sole), T_3:lentil (sole), T_4:maize + lentil (1:1), T_5:maize + pea (1:1) and six fertility levels *viz*., F_1:75% of recommended dose, F_2:100% of recommended dose, F_3: 125% of recommended dose, F_4: 50% of recommended dose +12.5% through FYM +12.5% through vermi-compost, F_5: 75% of recommended dose +12.5% through FYM +12.5% through vermi-compost, F_6:100% of recommended dose +12.5% through FYM +12.5% through vermi-compost was laid out in split-plot design replicated three times to see the residual effect on yield of *kharif* maize. The recommended dose of fertilizer applied @ 175 Kg N, 60 Kg P_2O_5 and 30 Kg K_2O/ha during *rabi* season. After the harvest of winter maize the soil samples were collected from different treatment plots and analyzed to determine the mechanical and chemical status of soil. The *kharif* maize (variety K-517) was sown after the harvest of winter maize on 12th June and 15th June and harvested on 10th September and 13th September during 2008 and 2009, respectively. To the *kharif* maize only the recommended dose of 90 Kg N, 60 Kg P and 30 Kg K /ha was applied. Full dose of P and K was applied as basal and nitrogen was applied in three equal splits with one third of which at the time of sowing, one third in mid of July at knee high stage and the remaining one third was applied at pre-tasseling stage. The quantities of FYM and vermi-compost for respective treatments in the *rabi* season have been worked out on nutrient N-basis. The plant and cob samples from different plots after harvest were taken, sun dried and analysed to determine the nutrient content in the grain and stover. The nutrient uptake was determined by using the standard formula and converted into Kg ha-1. The maximum and minimum temperature during the crop growing season ranged from 31.6 to 38.9 °C and 2.2 to 26.8 °C in 2008 and temperature ranged from 31.8 to 42.3 °C and 5.3 to 23.4 °C, respectively in crop season 2009.

Results and Discussion

Soil status after the harvest of winter maize intercropping systems and fertility levels

Different treatments of intercropping systems and fertility levels did not produce variation in soil pH and EC after the harvest of winter maize and component crops (Table 1) during both the years. Organic carbon was significantly influenced by intercropping system. During respective years significantly higher organic carbon status (0.41 and 0.42%) was observed in pea sole treatment which was statistically at par with lentil sole (0.40 and 0.42%) but significantly higher than sole maize (0.37 and 0.39%). Variation in organic carbon content was observed non-significant due to various fertility levels. An increase in the organic carbon with the increase in fertility levels was also found. These findings are in agreement with findings of (Reddy and Reddy, 1999) [10]. The favourable effects of nutrients on better crop growth and mineralization of crop residues may be the reason for improvement in the organic carbon content. The available N, P and K status of soil after the harvest of winter maize and component crop (Table 1) showed that P and K were not significantly influenced by intercropping systems. However, available N recorded in sole peas (228.24 and 228.92 Kg ha-1), sole lentil (227.66 and228.73 Kg ha-1), maize + peas (227.75 and 228.22 Kg ha-1) and maize + lentil (227.26 and 228.21 Kg ha-1) was similar but significantly higher than sole maize (225.65 and 226.91 Kg ha-1) during both years. Improvement of N status of soil might be due to symbiotic N fixation by legumes. These findings corroborate the results of (Enin and Clegg, 2001) [3]. Under different fertility levels, available P and K did not differ significantly during 2007-08 but in the year 2008-09, P and K was significantly influenced by the fertility levels. The available soil P and K recorded either at 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi- compost (10.24 and 168.19 Kg ha-1) or 125% recommended fertilizer dose (10.12 and 167.75 Kg ha-1) was similar but significantly higher over other fertility levels which differed significantly from each other exhibiting increase with the increase in fertility levels. Similar findings were noticed by (Tripathy, 1993) [13]. Available soil N status marked identical trend during both the years as that recorded for P and K status during second year of study. Similar findings of integrated use of organic and inorganic fertilizer was reported by (Hensh, *et al*., 2020) [4].

Effect on grain and stover yield and harvest index of succeeding maize crop

Although, Maize equivalent yield (Fig 1 & 2) in *rabi* season was maximum in maize + peas intercropping system i.e, 87.19 and 94.60 q ha-1 during both the years of study but data on grain yield of succeeding maize crop (Table 2) indicated that grain yield of maize sown after sole peas recorded 38.71 and 40.05 q ha-1 during 2007-08 and 2008-09, respectively which was statistically at par with those grown after sole lentil (38.28 and 39.79 q ha-1), maize + peas (38.51 and 39.85 q ha-1), maize + lentil (37.71 and 39.22 q ha-1) but significantly superior to the sole maize (35.64 and 36.54 q ha-1). Mean data of two years also showed similar trend. Data presented in 2 revealed that stover yield of *kharif* maize during both the years was also significantly influenced by preceding *rabi* crops. Straw yield recorded after sole peas (113.73 and 114.50 q ha-1 in 2007-08 and 2008-09) was statistically at par with sole lentil (113.34 and 114.28 q ha-1), maize + peas (113.18 and 113.84 q ha-1), maize + lentil (112.90 and 113.73 q ha-1) but significantly superior when followed after sole maize (109.69 and 110.30 q ha-1). Higher values of grain and stover yield of succeeding maize registered after sole peas and sole lentil might be due the high yield attributes i. e, cobs /plant, grains/cob and 100-grain weight (Fig.1 and 3) and might be owing to improved N status of soil due to the more symbiotic N fixation by sole peas and lentil (Peterson and Varvel, 1989, Suwanarit *et al*., 1986) [7, 11].

As regards to fertility levels, the minimum grain yield was recorded (34.02 and 35.09 q ha-1) when sown after 75% recommended dose which was significantly lower than 100% recommended dose (37.63 and 38.97 q ha-1) but at par with 50% recommended dose + 12.5% through F.Y.M +12.5% through vermi- compost. In turn yield attributes (Fig. 2 & 4)

and grain yield recorded at 100% recommended dose was significantly lower than 125% recommended dose whether applied through inorganic sources or in combination with organic sources but statistically at par with 75% recommended dose + 12.5% through F.Y.M +12.5% through vermi- compost (38.46 and 39.80 q ha-1). Similarly the mean values of two years exhibited the same trend. Improvement in residual fertility status may be the reason to increase higher yield of kharif maize in maize-maize. Increase in yield with increasing level of fertilizer was reported by (Porwal, 2000) [8]. Similar trend was observed in stover yield of *kharif* maize as recorded in grain yield of *kharif* maize crop during both the years under various fertility levels of preceding crop. The minimum straw yield (109.74 and 110.10 q ha-1) was recorded when grown after 75% recommended dose and increased with increase in the fertility levels in the preceding crop. The maximum stover yield was recorded at 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi - compost (114.81 and 115.91 q ha-1) and found significantly superior to 75% recommended dose. Harvest index of kharif maize was not significantly influenced by the intercropping systems. Data presented in Table 4.11 revealed that the minimum value of harvest index of *kharif* maize recorded with 75% recommended fertilizer dose increased with the increase in fertility levels upto 125% recommended dose applied through inorganic souces or in combination with organic sources during both the years of study. The better partitioning of photosynthates from source to sink and proportionate increase in the grain yield on account of higher plant height and dry matter accumulation may be the reason for higher harvest index recorded after higher fertility levels.

Effect on nutrient uptake by grain and stover of succeeding maize crop

The nutrient uptake by grain and stover was significantly influence by intercropping systems. Significantly higher N, P and K uptake was found in sole peas which was at par with sole lentil, maize + peas and maize + lentil intercropping systems (Table3). Increase in uptake might be due to higher N, P and K concentration and hence sufficient nutrient supply to maize sown after sole peas, sole lentil, maize + peas and maize + lentil intercropping systems. Similar findings were reported by (Manan, 2008) [5].

Among fertility levels, significantly higher nutrient uptake were recorded at 100% recommended dose + 12.5% through F.Y.M +12.5% through vermi-compost. The favorable effects of fertilization could be well expected in light of enhanced recovery of N, P and K in the crop under increased levels compared to 75% recommended dose. The results corroborate the findings of (Rao and Bhardwaj, 1981) [9].

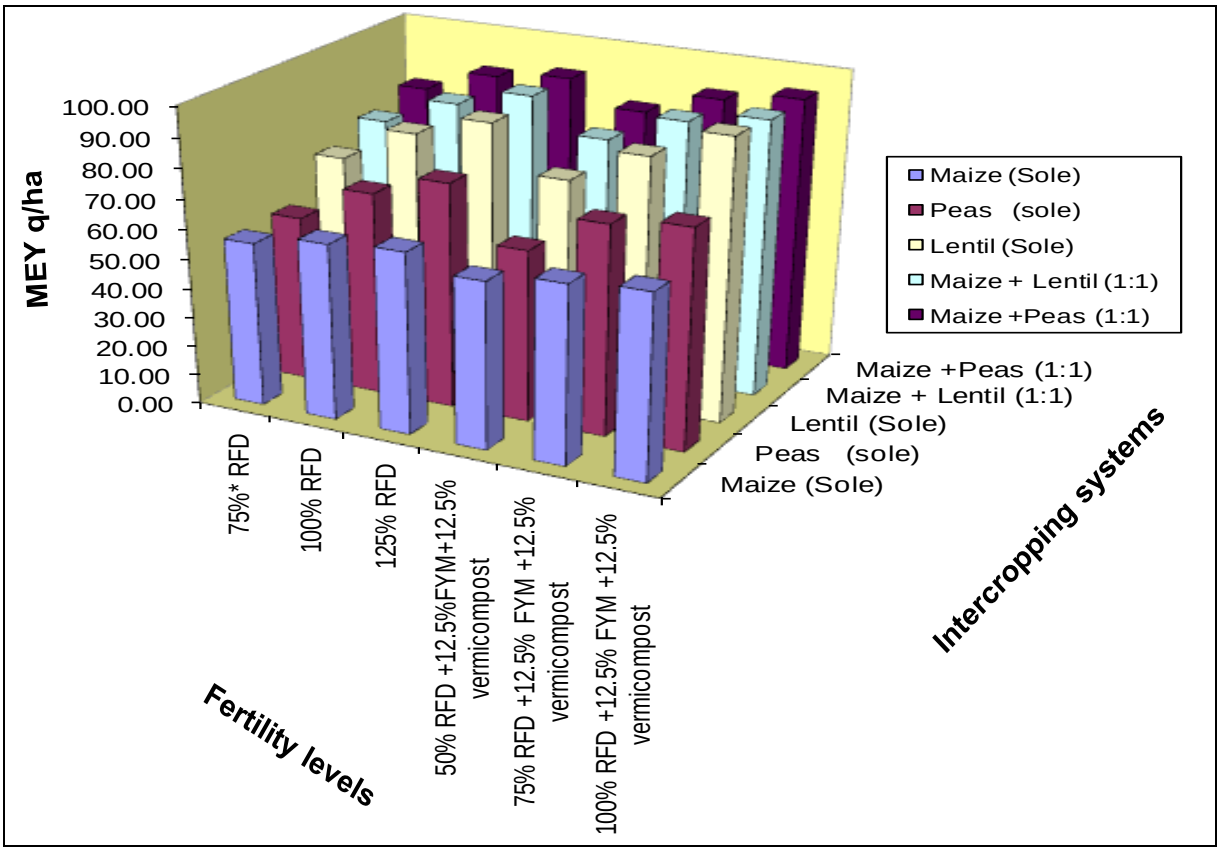

Fig 2: Maize equivalent yield as influenced by inter cropping systems and fertility levels of preceeding crop (2007-08)

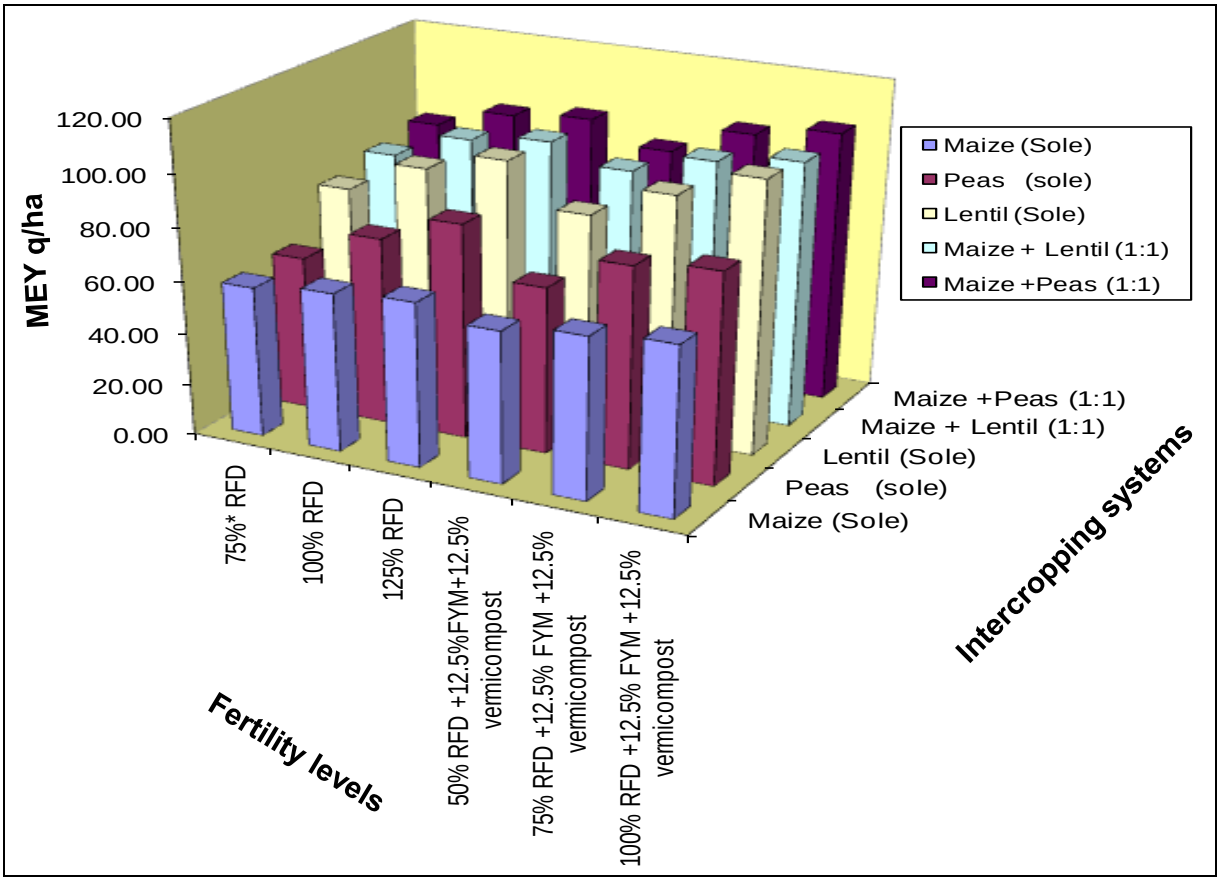

Fig 2: Maize equivalent yield as influenced by inter cropping systems and fertility levels of preceeding crop (2008-09)

Table 1: Effect of intercropping systems and fertsility levels on soil pH, EC, organic carbon and available N, P and K after harvest of winter maize and component crop.

Treatments	pH		EC (dSm^{-1})		Organic carbon (%)		N		P		K	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Intercropping systems												
T_1: Maize (Sole)	7.78	7.78	0.16	0.16	0.37	0.39	225.65	226.91	7.58	8.69	166.26	166.30
T_2: Peas (sole)	7.78	7.79	0.17	0.16	0.41	0.42	228.24	228.92	7.84	9.92	165.58	167.65
T_3: Lentil (Sole)	7.78	7.80	0.16	0.17	0.40	0.42	227.66	228.73	7.69	9.78	166.11	167.51
T_4: Maize + Lentil (1:1)	7.76	7.78	0.17	0.17	0.38	0.40	227.26	228.21	7.65	9.71	165.30	166.48
T_5: Maize +Peas (1:1)	7.78	7.80	0.16	0.17	0.39	0.40	227.75	228.22	7.68	9.76	165.47	165.84
CD (p=0.05)	NS	NS	NS	NS	0.02	0.01	1.43	1.25	NS	NS	NS	NS
Fertility levels												
F_1:75% * RFD	7.77	7.78	0.16	0.17	0.38	0.39	226.44	226.37	7.57	8.87	164.43	165.47
F_2:100% RFD	7.78	7.79	0.17	0.17	0.39	0.41	227.21	228.02	7.62	9.40	165.89	166.83
F_3:125% RFD	7.78	7.80	0.17	0.17	0.40	0.42	228.17	229.39	7.75	10.12	166.17	167.75
F_4:50% RFD+12.5%FYM+12.5% vermicompost	7.77	7.78	0.16	0.16	0.39	0.39	226.17	226.76	7.60	8.90	165.06	165.92
F_5:75% RFD +12.5% FYM +12.5% vermicompost	7.78	7.80	0.17	0.17	0.40	0.42	227.31	228.67	7.70	9.51	166.29	167.18
F_6:100% RFD +12.5% FYM +12.5% vermicompost	7.79	7.80	0.16	0.17	0.41	0.43	228.18	229.88	7.88	10.24	166.61	168.19
CD (p=0.05)	NS	NS	NS	NS	0.11	0.01	0.50	1.11	NS	0.35	NS	0.51
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Recommended fertilizer dose of winter maize: 175 Kg N, 60 Kg P_2O_5 and 30 Kg K_2O ha^{-1}

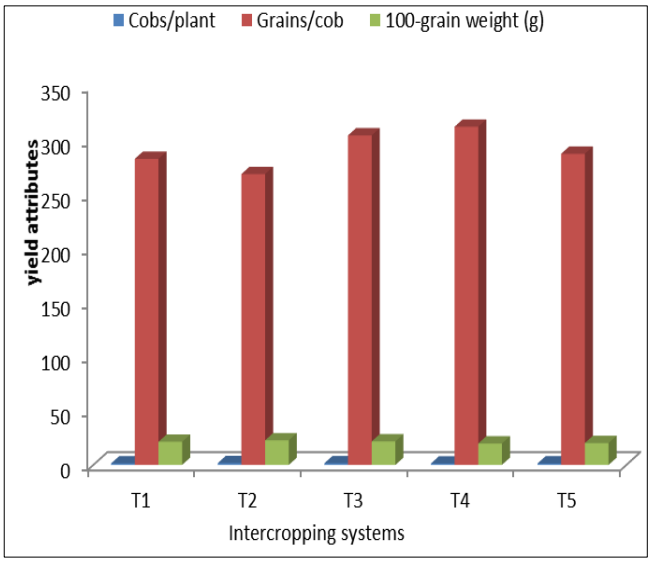

Fig 3: Effect of intercropping systems on yield attributes of succeeding maize crop during 2007-08

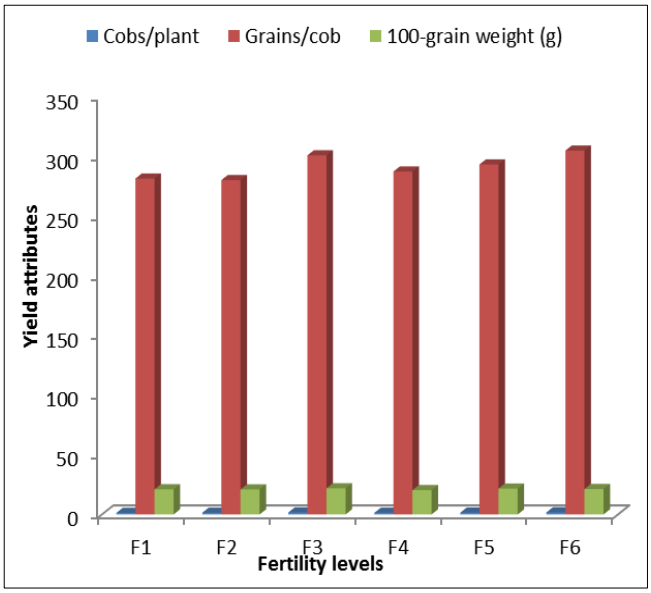

Fig 4: Effect of fertility levels on yield attributes of succeeding maize crop during 2007-08

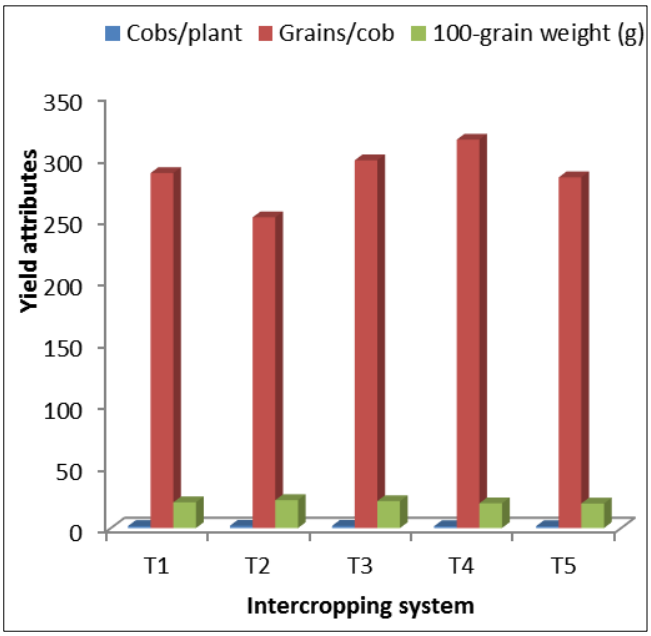

Fig 5: Effect of intercropping systems on yield attributes of succeeding maize crop during 2008-09

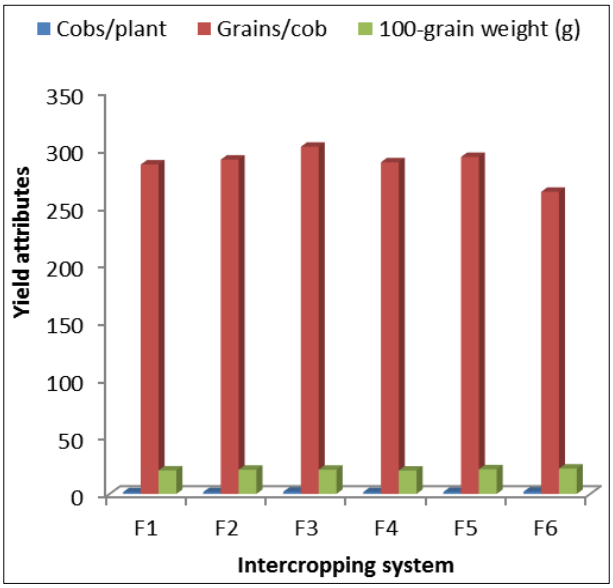

Fig 6: Effect of fertility level on yield attributes of succeeding maize crop during 2008-09

Table 2: Effect of intercropping systems and fertility levels on grain and stover yield (q /ha) and harvest index (%) of succeeding Kharif maize crop

Treatments	Grain		Stover		Harvest index (%)	
	2008	2009	2008	2009	2008	2009
Intercropping systems						
T_1: Maize (Sole)	35.64	36.54	109.69	110.30	24.46	24.81
T_2: Peas (sole)	38.71	40.05	113.73	114.56	25.30	25.82
T_3: Lentil (Sole)	38.28	39.79	113.34	114.28	25.23	25.80
T_4: Maize + Lentil (1:1)	37.71	39.22	112.90	113.73	26.32	26.96
T_5: Maize +Peas (1:1)	38.51	39.85	113.18	113.84	26.71	27.27
SEm(+)	0.57	0.62	0.49	0.46	0.33	0.40
CD (p=0.05)	1.78	2.02	1.60	1.50	NS	NS
Fertility levels						
F_1:75% * RFD	34.02	35.09	109.74	110.10	23.80	24.30
F_2:100% RFD	37.63	38.97	112.79	113.62	25.46	25.99
F_3:125% RFD	39.95	41.03	114.73	115.56	26.49	26.87
F_4:50% RFD +12.5%FYM+12.5% vermicompost	35.02	36.66	109.56	110.13	24.37	24.87

F_5:75% RFD +12.5% FYM +12.5% vermicompost	38.46	39.80	112.97	113.93	25.88	26.38
F_6:100% RFD +12.5% FYM +12.5% vermicompost	40.75	42.69	114.81	115.91	26.82	27.58
SEm(+)	0.67	0.61	0.47	0.47	0.35	0.39
CD (p=0.05)	1.90	1.71	1.34	1.33	0.99	1.09
Interactions	NS	NS	NS	NS	NS	NS

*Recommended fertilizer dose of winter maize: 175 Kg N, 60 Kg P_2O_5 and 30 Kg K_2O ha^{-1}

Table 3: Effect of intercropping systems and fertility levels on NPK uptake (Kg ha-1) in grain and stover of succeeding *Kharif* maize crop.

Treatments	2008						2009					
	Grain			Stover			Grain			Stover		
Intercropping systems	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1: Maize (Sole)	25.23	7.50	11.98	33.24	17.75	50.34	25.41	7.80	12.23	34.30	18.98	49.47
T_2: Peas (sole)	32.77	9.23	13.52	39.56	20.30	56.32	33.51	10.76	14.67	40.73	21.49	57.25
T_3: Lentil (Sole)	31.41	8.51	13.04	38.51	19.64	55.61	32.65	10.37	14.51	40.35	21.40	57.04
T_4: Maize + Lentil (1:1)	30.38	8.49	12.80	37.05	19.32	54.22	29.96	9.54	13.92	38.56	20.40	54.39
T_5: Maize +Peas (1:1)	30.61	8.47	12.82	37.85	19.34	56.29	31.34	9.96	14.01	39.69	20.78	55.32
SEm(+)	1.08	0.30	024	1.03	0.36	0.68	0.80	0.43	0.49	0.80	0.37	0.97
CD (p=0.05)	3.50	0.96	0.78	3.28	1.18	2.22	2.59	1.39	1.60	2.59	1.21	3.17
Fertility levels												
F_1:75% * RFD	24.36	6.88	10.84	30.71	15.73	49.85	25.59	7.99	12.30	31.88	17.29	50.53
F_2:100% RFD	28.98	8.25	12.29	34.56	19.50	54.60	30.41	9.76	13.50	36.40	21.32	55.28
F_3:125% RFD	35.90	9.32	14.62	45.68	22.11	58.23	34.93	10.83	14.89	46.72	22.87	57.15
F_4:50% RFD +12.5%FYM+12.5% vermicompost	24.86	7.29	11.21	31.19	16.18	50.31	26.29	8.40	12.67	32.76	17.74	51.66
F_5:75% RFD +12.5% FYM +12.5% vermicompost	29.35	8.95	12.79	35.08	19.82	55.90	30.78	10.06	14.01	36.92	21.38	56.05
F_6:100% RFD +12.5% FYM +12.5% vermicompost	36.52	9.83	15.15	46.23	22.28	58.46	35.43	11.08	15.82	47.67	23.04	57.51
SEm(+)	0.75	0.25	0.26	0.65	0.65	0.63	0.86	0.28	0.60	0.60	0.75	0.98
CD (p=0.05)	2.14	0.72	0.75	1.97	1.84	1.78	2.43	0.80	1.70	1.70	2.13	2.79
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Recommended fertilizer dose of winter maize: 175 Kg N, 60 Kg P_2O_5 and 30 Kg K_2O ha^{-1}

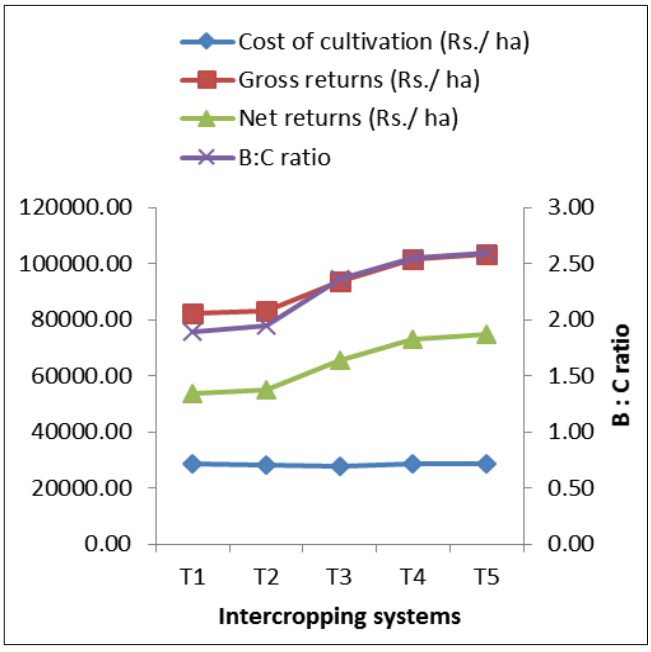

Fig 7: Effect of intercropping systems on relative economics during 2007-08

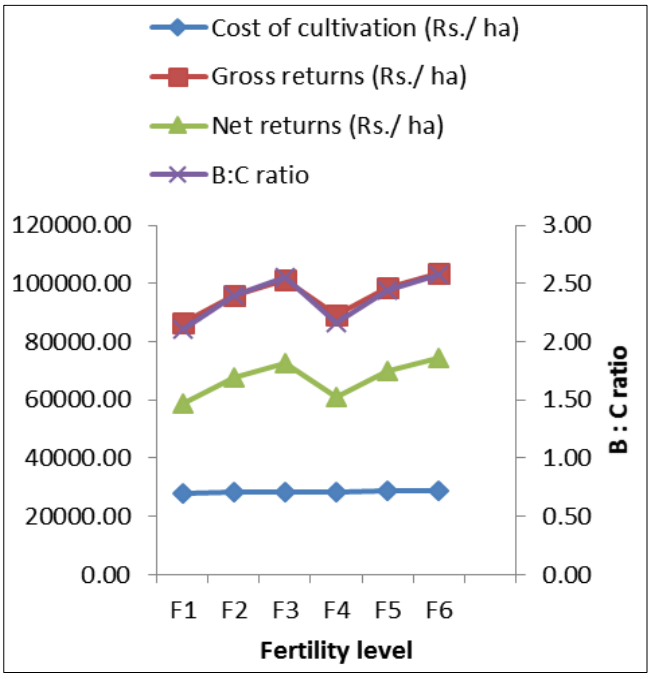

Fig 8: Effect of fertility levels on relative economics during 2007-08

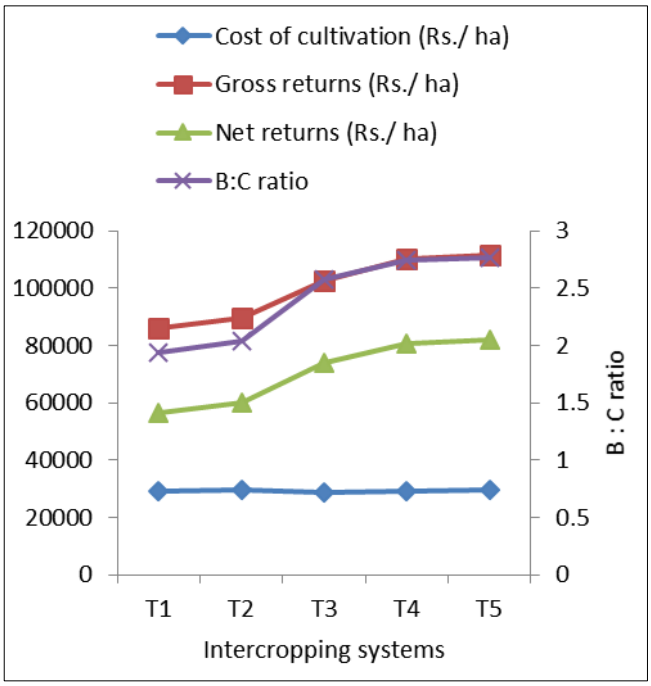

Fig 9: Effect of intercropping systems on relative economics during 2008-09

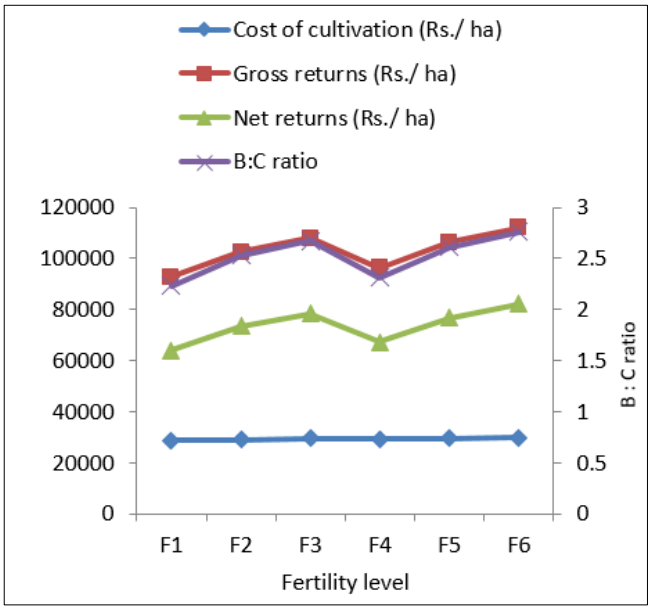

Fig 10: Effect of fertility levels on relative economics during 2008-09

Economics

As depicted in Fig. 7 & 9, the gross returns, net returns and B:C ratio, the intercropping systems, maize + peas intercropping system recorded an increase of 25.71 and 38.70% and 29.93 and 44.64% with respect to gross and net returns over sole maize in 2007-08 and 2008-09, respectively. The B:C ratio was also recorded higher under same treatment i.e, 2.59 and 2.77 during 2007-08 and 2008-09, respectively (Misra *et al*., 2001) [6].

Among the fertility levels (Fig. 8 & 10), The gross returns, net returns and B:C ratio increased with the increase in fertility levels. An increase in values of gross returns and net returns were found at 100 per cent recommended dose + 12.5 per cent through F.Y.M +12.5 per cent through vermi-compost to tune of 19.63 and 27.02% and 20.88 and 28.47% over 75 per cent recommended dose during 2007-08 and 2008-09, respectively. The B:C ratio was also recorded higher i. e, 2.58 and 2.76 under same fertility levels (Thakur *et al*., 1988) [12].

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