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Effect of intercropping wheat (*triticum aestivum.L.*) with mustard (*brassica juncea*) on yield and economics under organic system of cultivation

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Abstract— *Wheat is the most important food grain among the cereal grain crops. In India, wheat demand increases because of an increase in population and diet changes among the people.and wheat occupies 2nd place over the rice. The research was conducted with the aim of checking out the suitable row proportion while wheat was intercropped with mustard under different organic manures and biofertilizers. The field experiment was conducted at the farm of Lovely Professional University, Phagwara, on wheat (Triticum aestivum.L) intercropped with mustard (Brassica junecea.L) during the rabi season in the years 2020–2021. A split plot block design was used with three row proportions of wheat + mustard intercropping (3:1) (2:2) and sole wheat (the main crop),and four treatments of different manures and biofertilizers, and three replications. Based on the complete analysis of the experimental results, it is concluded. that different treatments affected the wheat + mustard intercropping, there was a significant increase in growth parameters, yield attributes, and yield. Among the geometries, G1 (sole wheat) showed good results in biological, economical, straw yield, and harvest index in M4 (vermicompost 5 t/ha + Azospirillum + PSB) in all geometries. There is no significant increase in harvest index in all geometries and treatments. Higher gross returns were absorbed in (3:1) wheat + mustard intercropping in the treatment (G3M4 Vermicompost 5t/ha + PSB + Azospirillum), and the highest net returns were increased was observed in Geometry 2 (2:2 wheat + mustard) of treatment no:3 (M3 poultry manure 5t/ha + PSB + Azospirillum). The highest benefit-cost ratio (2.27) was observed in Geometry 2 (2:2 wheat + mustard intercropping) of treatment M3 (poultry manure + azospirillum + psb)).Hence, research outcomes (2:2) of wheat + mustard intercropping by applying M3 poultry manure along with biofertilizers are beneficial to farmers.*

Keywords— ***Economics, organic manures, biofertilizers, Row ratio, wheat + mustard intercropping, sole wheat, geometries, beneficial, farmers.***

I. INTRODUCTION

Intercropping plays a major role in organic cultivation. this type of cultivation, intercropping involves between two or more crops with row arrangements and different types of patterns at the same time and same field. Intercropping is noted as a useful agronomical practice to increase the yields and quality of the environment in the area through agricultural production. Intercropping of wheat and mustard is an old age practice mainly in the northern part of India for the purpose of stability and the necessity of oil and grains both. now adays intercropping may be raise due to produce higher yields than monocropping or sole cropping.Row ratios in intercropping play a major role in wheat and mustard. In recent times, row intercropping has produced higher yields than mixed cropping. recommended row ratio to be preferred for the farmers to attain higher yields from available resources more effectively on a sustainable basis. With variation in row ratio, growth and development of both

crops are also being diverted,which eventually affects the yield attributes or yield,but aparticular crop ratio LER and yield profit surely increase. Thus, recommendations have been made by scientists for various locations or areas. Due to the change in various weather conditions, climatic changes may vary from place to place, as may the types of cultivation practices and cultivation varieties. The research analysis is satisfied with wheat + mustard intercropping in relation to management of irrigation, fertiliser recommendations,genotypes, and crop geometries. Hence, the upcoming research must focus on studies of crop competition on row ratios,growth and development studies on intercropping, and mainly yield attributes and advantages of intercropping by using agro-techniques to get more yields. In organic farming, manures plays a major role. Manures are nutrient-rich plant and animal wastes. During decomposition, they emit nutrients. the art of gathering and using waste from livestock, human, and 14 vegetable sources to improve crop production. Manures are organic materials made from animal, human, and plant waste that produce diverse plant nutrients.

II. LITERATURE REVIEW

Intercropping is also described as the cropping method in which two or more crop species are grown simultaneously in the same area, with crops having the same growing season [Ofori and Stern, 1987].

Intercropping systems avoid the risk of various pests and diseases. It also enhances the absorption of sunlight, fertilisers, and water absorption. The rate of absorption of sunlight, water, and fertiliser is greater in amounts when compared to a sole crop. Intercropping also helps in overcoming the unfavourable climatic conditions in areas with uneven environmental conditions. (Rathi and Verma, 1979)

Intercropping is more beneficial than sole crops, as sole crops do not make use of all the available resources. In the intercropping system, the selected crop species are sown in parallel in order to increase crop production. There will be an upsurge in crop production with space utilisation and time management. (Ahlawat and Sharma, 2002).

In order to obtain greater yield benefits, a suitable row ratio and distance should be required in the management of intercropping in wheat and mustard, as aerial competition arises between these two crops when they are grown together at various sowing amounts. (Bora,1999)

In order to increase the yield in intercropping, the agronomic study of the arrangement of plants and also the total number of plants and number of plants in component crops is required (Willey, 1979b).

In addition, Saini et al. (1989) also reported that growing one row of mustard with eight or nine rows of wheat increased the yield of mustard seeds by about 2–3 quintals per hectare without damaging the yield of wheat.

III. MATERIALS AND METHODS

An experiment was conducted at the field Department of Agronomy, school of Agriculture, Lovely Professional University, Phagwara, on wheat + mustard intercropping during late November in the year 2020-2021 with the title —"To study the effect of intercropping wheat (Triticum *aestivum*) with mustard (Brassica *juncea*) on yield and economics under an organic system of cultivation".

The experiment was laid out in a split-plot design comprising three row proportions of wheat + mustard intercropping, i.e., 3:1, 2:2, and sole wheat, in main-plots, and four different treatments of manures, along with two biofertilizers of farmyard manure,poultry manure,vermicompost, azospirillum, and phosphate solubilizing bacteria (PSB) in sub-plots. Thus, total twelve {(3 main-plots x 4 sub-plots)} treatment combinations were formed. The treatments were allocated to each plot randomly using a random number (Fisher and Yates, 1963) and replicated three times. The main plot and subplot treatments, as well as the sole crop (wheat), were also randomized separately using the said random number. Details of the treatments and their combinations used in the experiment are given in the below table.

Main plot:(crop ratio)

S. No	GEOMETRY
G1	(100% Wheat)sole wheat
G2	50 % wheat + 50% mustard **(2:2)**
G3	75 %wheat + 75% mustard **(3:1)**

Sub plot: Four different treatments of manures along with two biofertilizers

Sub plots	Treatment
M1	Control
M2	FYM + azospirillum & psb
M3	Poultry manure + azospirillum & psb
M4	Vermicompost + azospirillum & psb

Experimental site location:

Experiment was conducted at the farm of lovely professional university Phagwara district kapurthala late forth november in year 2020-2021. The farm is

situated at ^{0}3122'31.81'' North latitude and ^{0}7523'03.02‖ East longitude with 252m average elevation above mean sea level. It is at 350 km distance from capital of India (Delhi) in Punjab fall under sub tropical region in central plane of state agro climatic zone.

Weather and climatic condition:

Region of experimental site comes under sub tropics with cool weather in winter season, hot weather in summers and distant rainfall period in month of July, August and September. South west monsoon is main source of rainfall in this region. During winter season the temperature never goes below zero degree especially in the month of December and January. Highest temperature reached 42^{0}c during summer month April, May and June.

1.Sole Wheat

2. (Wheat + mustard intercropping (2:2) Ratio

3. (Wheat + mustard intercropping (3:1) Ratio

Meteorological data of growing season

Month	Temperature			Relative Humidity (%)	Rainfall (mm)
	Min	Max	Avg		
Nov (2020)	11.5	25.1	18.3	69.2	15
Dec (2020)	7.5	20.6	14.05	69.8	21
Jan (2021)	6.1	18.5	12.3	75	48.4
Feb (2021)	8.5	22.2	15.35	67.7	74
Mar (2021)	14	29	21.5	61.5	62
Apr (2021)	18	34	26	38.5	38

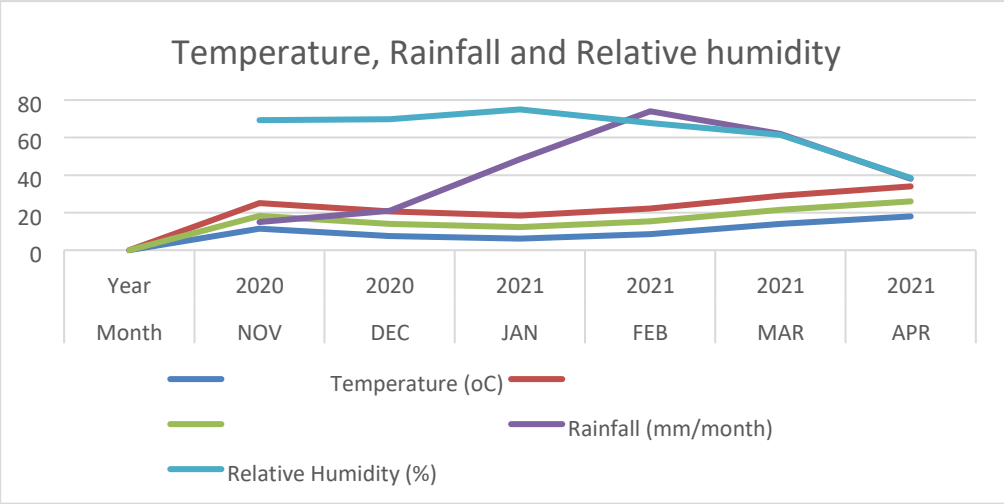

Fig.1 Temperature rainfall and rainfall and relative humidity

IV. RESULTS & DISCUSSION

Table.1 Effect of row proportions, and different types of manures on yield of wheat.

GEOMETRIES	Biological yield	Grain yield	Straw yield	Harvest index
Row proportions				
Sole wheat	126.2	53.45	72.40	42.25
2:2 wheat + mustard	73.16	30.85	42.30	42.20
3:1 wheat + mustard	88.58	37.84	50.74	42.80
SE(m±)	1.426	0.749	0.204	0.942
CD (P=0.05)	5.75	3.01	4.85	NS
Treatments				
Control	77.55	32.92	44.10	42.60
Fym + azospirillum+psb	98.0	41.21	56.78	42.07
poultry + azospirillum +psb	101.4	43.21	58.23	42.56
vermicompost+azospirillum+psb	107.0	45.52	61.47	42.43
SE(m±)	1.091	0.728	0.257	0.997
CD (P=0.05)	3.26	2.18	3.76	NS

Grain yield (q/ ha^{-1})

A critical examination of the data on wheat grain yield was presented in the above table 1. While comparing the treatments,the grain yield was higher in (M4) (Vermicompost + azospirillum + Psb) than in (M_3)(poultry manure + azospirillum + Psb) & (M_2)(fym + azospirillum + psb).Hence, all the treatments recorded significantly higher grain yields than the control treatment. Different row proportions exhibited perceptible variation in the wheat grain yield in Intercropping of wheat + mustard in (G_1) (sole) row proportion significantly recorded maximum grain yield over the both row proportions of (3:1)(wheat + mustard) & (2:2)(wheat + mustard), respectively; however, (3:1)(wheat + mustard) recorded significantly higher than (2:2)(wheat + mustard),and lower than G_1(sole). However, the lowest grain yield was observed in the (2:2)(wheat + mustard) row proportion. Hence, wheat in a pure stand recorded a significantly higher grain yield than the intercropping mean.

Table.2. Effect of row proportions, and different types of manures on gross returns, net returns and benefit cost ratio in wheat + mustard intercropping.

GEOMETRIES	Gross returns	Net returns	Benfit cost ratio
Row proportions			
Sole wheat	1,21,491.60	53,789.00	1.792
2:2 wheat + mustard	1,36,825.40	69,122.84	2.032
3:1 wheat + mustard	1,24,689.10	56,986.58	1.843
SE(m±)	1,516.76	1,516.78	0.023
CD (P=0.05)	6,115.01	6,115.09	0.093
Treatments			
Control	1,04,173.30	46,083.22	1.793
Fym + azospirillum+psb	1,29,173.70	59,933.67	1.866

poultry + azospirillum +psb	1,34,836.60	70,596.45	2.099
vermicompost+azospirillum+psb	1,42,491.30	63,251.22	1.798
SE(m±)	1,388.90	3,033.56	0.021
CD (P=0.05)	4,158.59	8,067.45	0.062

Economics

B:C Ratio

Benefit cost ratio is the key factor that denotes the how the farmer is benefited from his input application to the field for crop production and how the returns are obtained. If the returns are more as to cost of cultivation. Better the B: C ratio more the benefit resulted. Benefit cost ratio have shown significant variance among geometry treatments.

From the data obtained highest benefit cost ratio (**2.27**) were observed in Geometry 2 (2:2 wheat + mustard intercropping) of treatment no. M3 (poultry manure + azatobactor + psb)) and within the geometry's G1M3, G3M3,G2M1 and G2M2 (2.26, 2.20,2.19 and 2.10) have shown highest B: C ratio as to other treatments within the geometry's. In geometry treatments comparison of G1 (sole wheat) while comparing with control plot G1T1 (1.69) all treatments G1M3,G1M2,and G1M4 (2.26,2.05,1.83) have shown better B: C ratio. In geometry 2 (2:2 wheat + mustard) while comparing with control G2M2 and G2M4 shows lesser bc ratio.and G2M3 were heighest bc ratio among all the treatments in a geometry. In geometry 3 (3:1 wheat + mustard) control plot G3M1 (1.86) other treatments G3M3 and G3M4 (2.20 and 1.95) have shown better B: C ratio while G3T2 (1.82) have shown lowest B: c ratio as to control plot. Among total G1M1, G3M2, G1M4 and G3M1 have shown lowest B: C ratio.Hence among all geometries and treatments the lowest bc ratio were recorded in G1M1(control) and significantly highest bc ratio were recorded in G2M3(2:2 poultry + azospirillum + psb) and which was statistically par at G1M3 sole(poultry + azospirillum + psb). Benefit cost ratio of different geometry treatments were shown in above table 2.

V. CONCLUSION

By applying manures and biofertilizers in wheat + mustard intercropping, there was a significant increase in spike length, spike weight, number of spikelets spike^{-1}, number of grains spike^{-1}, number of siliqua/seed, stover yield, biological yield, yield, harvest index, and 1000 seed weight. There was no significant increase in all geometries. By applying of (M4 vermicompost+azospirillum +psb)there was a significant increase compared to the control. There was a further significant increase when applied (M3 poultry manure+ azospirillim + psb). There was no significant increase in both the geometries and all treatments of harvest index for both the crops. There was a significant increase in yield in (M4 vermicompost + azospirillum + psb) in all geometries of wheat + mustard intercropping for both crops.

Economics: Higher gross returns were observed in the (3:1) wheat + mustard intercropping (**Rs.1, 55,089 /ha**) were observed in the treatment (G3M4 Vermicompost 5t/ha + PSB + Azospirillum) and the highest net returns was increased in (**Rs.81,809/ha**) were observed in Geometry 2 (2:2 wheat + mustard) of treatment no 3 (M3 poultrymanure 5t/ha + + PSB + Azospirillum). The highest benefit-cost ratio (**2.27**) was observed in Geometry 2 (2:2 wheat + mustard intercropping) of treatment no. M3 (poultry manure + azatobactor + psb)).Hence, (2:2) wheat + mustard by applying of poultry manure along with biofertilizers is beneficial to farmers.

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