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EFFECT OF SOWING METHODS AND ROW RATIO ON AGRONOMIC ADVANTAGES, COMPETITION FUNCTIONS AND ECONOMICS OF WHEAT (*Triticum aestivum* L.) + CHICKPEA (*Cicer arietinum* L.) INTERCROPPING

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ABSTRACT

A field experiment was carried out during the *rabi* 2020-21 to study the effect of different sowing methods and row ratio on agronomic advantages, competition functions and economic viability of wheat + chickpea intercropping. The field experiment was laid out in split-plot design with two methods of sowing *viz*., happy seeder and rotavator in main plots with four intercropping system *viz*., (wheat + chickpea 1:1, wheat + chickpea 1:2, wheat + chickpea 2:1, wheat + chickpea 2:2 row ratio) along with sole wheat and sole chickpea in sub plots with three replications. The results indicated that the happy seeder was recorded significantly higher gross returns (Rs. 127262 ha^{-1}), net returns (Rs. 91177 ha^{-1}) and benefit: cost ratio (3.52) than rotavator method of sowing. The maximum wheat equivalent yield (60.36 q ha^{-1}) and land equivalent ratio (1.25), area time equivalent ratio (1.21) was recorded in wheat + chickpea (2:1) row ratio than all other intercropping system. Significantly higher gross returns (Rs. 142889 ha^{-1}), net returns (Rs. 105694 ha^{-1}) and benefit: cost ratio (3.85) was recorded in wheat + chickpea 2:1 row ratio than all other intercropping systems and sole wheat and chickpea. Wheat + chickpea 1:2 row ratio recorded maximum value of aggressivity (0.92) and competitive ratio (2.03) in wheat.

(Key words: Happy seeder, rotavator, intercropping, row ratio, wheat, chickpea, economics)

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to family poaceae, is the most widely cultivated food crop in the world. It compares well with other important cereals in its nutritive value. Wheat grains contains more proteins compared to other cereals which are of special significance to maintain the good bread making quality due to the presence of a characteristic substance 'gluten' with relatively high content of niacin and thiamine (Singh *et al.*, 2020). Pulses are a smart food as these are critical for food basket (dal-roti, dalchawal), rich source of protein *i.e.*20-25 per cent which is double the protein content of wheat and thrice that of rice. Currently, India is the largest producer and consumer of pulses in world, but consumption exceeds production therefore, a wide gap is build between consumption and production of pulses. To bridge the this gap of pulses, there is an urgent need to increase the pulse production. Pulse production can be increased by growing pulses on favourable lands that are occupied by cereals and cash crops by way of intercropping (Praharaj and Blaise, 2016).

Chickpea (*Cicer arietinum* L.) is the important pulse crop of India. It is most consumed pulse in country and it contain 18-22 % protein, 61-62 % carbohydrate and 4.5% fat and also rich source of calcium, iron and phosphorus (Anonymous, 2018). It helps in reducing the malnutrition problem in country. Chickpea nourish the soil productivity by trapping the atmospheric nitrogen in their root nodules (Ali and Kumar, 2005). Paddy straw is the only organic material available in significant quantities to the farmers. Due to high silica content paddy straw is considered as poor feed for animals and remains unutilized. A large portion of the straw is being burnt by the farmers because burning of rice stubble is rapid and cheap option for farmer. The paddy straw contains a significant amount of essential plant nutrients which was lost by burning besides; it also causes a serious environmental pollution. Therefore, the *in-situ* management of paddy straw in the field is needed. To overcome, the problems of burning of paddy straw, happy seeder and rotavator machines were developed which help in direct sowing of crops without removal and burning of paddy straw. The conservation tillage, either crop residue retention or incorporation was found to be suitable for enhancing the crop yield (Kumar *et al.*, 2021).

MATERIALS AND METHODS

Field experiment was carried out during *rabi* season of 2020-21 at Students' Research Farm, Department of Agronomy, Khalsa College, Amritsar--, Punjab, India. The soil of the experiment field was sandy loam, having normal pH (8.4), normal EC (0.21 dSm^{-1}), low organic carbon (0.39%), low available N (179 kg ha^{-1}), medium available P (22 kg ha^{-1})

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and medium available K (296 kgha[1]), respectively during study. The field experiment was laid out in split-plot design with two methods of sowing *viz.,* Happy seeder and Rotavator in main plots with four intercropping system *viz.,*(wheat + chickpea 1:1, wheat + chickpea 1:2, wheat + chickpea 2:1, wheat + chickpea 2:2 row ratio) along with sole wheat and chickpea in sub plots with three replications. Wheat variety Unnat PBW 343 and chickpea variety PBG 7 were sown with happy seeder and with a seed drill after incorporation of rice residue with rotavator followed by planking on 1st November 2020. The seed rate of 100 kg ha^{-1} for wheat and 45 kg ha^{-1} for chickpea was used. All cultural practices were followed as per, recommended procedures.

Yield of individual crop was converted into wheat equivalent yield (WEY) (q ha^{-1}) on the basis of prevailing market price of the crop (Anjaneyulu *et al.,*1982). It was calculated by the following formula:

$$\text{WEY}=\frac{\text{Grain yield of wheat} + \text{Grain yield of chickpea x price of chickpea}}{\text{Price of wheat}}$$

Land equivalent ratio (LER) was calculated as per method given by Willey and Osiru (1972). It was calculated as follows:

$$\text{LER} = \text{LER (Wheat)} + \text{LER (Chickpea)}$$

$$\text{LER (Wheat)} = \frac{\text{Intercropped yield of wheat}}{\text{Sole crop yield of wheat}}$$

$$\text{LER (Chickpea)} = \frac{\text{Intercropped yield of chickpea}}{\text{Sole crop yield of chickpea}}$$

Competitive ratio (CR) was calculated by the formula proposed by Willey and Rao (1980).

$$\text{CRa} = \frac{\text{LERa}}{\text{LERb}} \times \frac{\text{Zba}}{\text{Zab}}$$

Where, CRa = Competition ratio for the component crop a

LERa = Land equivalent ratio of crop a

LERb = Land equivalent ratio of crop b

Zab and Zba are sown proportion of crop a and b in an intercropping system

Area time equivalent ratio (ATER) takes into account the duration of crops and permits an evaluation of crops on yield day^{-1} basis. It is modification of LER (Hiebsh and McCollum, 1987) and expressed as below:

$$\text{ATER}=\frac{(L_a \text{ x } D_a) + (L_b \text{ x } D_b)}{T}$$

Where,

L_a= Relative yield or partial LER of component crop wheat (q ha^{-1})

L_b=Relative yield or partial LER of component crop wheat (q ha^{-1})

D_a and D_b= Duration of component crop and intercrop (days)

T= Total duration of the intercropping system (days)

Aggressivity (A) shows the degree of dominance of one crop over other when sown together. Aggressivity value was calculated by the formula proposed by Gilchrist (1965).

$$\text{Aab} = \frac{\text{Yab}}{\text{Yaa} \times \text{Zab}} - \frac{\text{Yba}}{\text{Ybb} \times \text{Zba}}$$

Where, Aab = Aggressivity value for the component crop a

Yaa = Pure stand yield of crop a

Yab = Intercrop yield of crop a

Ybb = Pure stand yield of crop b

Yba = Intercrop yield of crop b

Zab and Zba are sown proportion of crop a and b in an intercropping system

Gross returns were calculated by multiplying the price of wheat and chickpea with their respective yields. Net returns were calculated by subtracting total cost of cultivation from the gross returns. Benefit : cost ratio was calculated by dividing the gross returns with total cost of cultivation under the respective treatment. The recorded data from the experiment was subjected to statistical test by following 'Analysis of variance technique' as described by Cochran and Cox(1967) and Cheema and Singh (1991). All the comparisons were made at 5 per cent level of significance.

RESULTS AND DISCUSSIONS

Grain yield of wheat and chickpea

In methods of sowing there was statically similar grain yield of wheat and chickpea was recorded in happy seeder and rotavator. However, slightly higher grain yield of wheat and chickpea (40.09 and 10.01 q ha^{-1}) was recorded happy seeder than (38.49 and 9.18 q ha^{-1}) in method of sowing. The results are similar to finding of Singh *et al.* (2013), who reported that there was no significant difference in grain yield between happy seeder and rotavator. In intercropping maximum grain yield of wheat was (48.10 q ha^{-1}) recorded in sole wheat which was statistically at par with (45.97 q ha^{-1}) wheat + chickpea in 2:1 row ratio but significantly higher than all other wheat + chickpea row ratios. The maximum yield of chickpea (17.44 q ha^{-1}) was recorded in sole chickpea which was significantly higher than all other wheat + chickpea row ratios (Table 1). Similarly, Sharma *et al.* (2018) found the maximum grain yield in sole wheat than intercropping. Sujatha *et al.* (2018) also reported the higher yield of pigeonpea in intercropping system of transplanting pigeonpea with greengram, soybean and blackgram at 1:2 row proportions as compared to growing of intercrops in sole direct pigeonpea and sole pigeonpea.

Wheat equivalent yield

The data revealed that variations in wheat equivalent yield with different intercropping treatments were significant. Among intercropping system wheat + chickpea 2:1 row ratio recorded maximum wheat equivalent yield (60.36 q ha^{-1}) and this was statistically at par with wheat + chickpea 1:2 (56.59 q ha^{-1}) but significantly higher than all other treatments (Table 1).The similar results were also found by Singh *et al.*(2017), who reported that wheat equivalent yield was significantly higher in wheat + chickpea (2:1) intercropping system. Sharma *et al.* (2015) also reported the higher wheat equivalent yield in intercropping system than sole wheat and chickpea.

Land equivalent ratio

Land equivalent ratio (LER) is the unit to measure the production efficiency of different intercropping system by converting the production in term of land acreage. It gives an accurate assessment of biological efficiency of intercrop. The data regarding the land equivalent ratio (LER), presented in Table 1revealed that wheat + chickpea intercropping system differed significantly in LER. Compared with sole cropping, all the intercropping systems resulted in significantly higher LER indicating the yield advantage in intercropping. The highest land equivalent ratio (1.25) was recorded in wheat + chickpea 2:1 row ratio and this was significantly higher than all other treatments.The results corroborated the findings of Singh and Aulakh (2015), who reported the highest LER in wheat + chickpea 2:1 than all other treatments. Similarly, Das *et al.*(2012) reported the higher LER values in wheat + chickpea intercropping system than the sole cropping.

Area time equivalent ratio

Land equivalent ratio (LER) showed the efficiency of using land area, but the time factor is not considered for which crop occupies the land area. To correct the limitation of the LER, the concept of area time equivalent ratio (ATER) has been developed considering the occupancy of land by the crop for certain periods. The value of area time equivalent ratio (ATER) more than unity gives advantages of intercropping. Compared with sole cropping, all the intercropping systems resulted in significantly higher area time equivalent ratio (ATER) indicating the yield advantage in intercropping (Table1). The highest area time equivalent ratio (1.21) was recorded in wheat + chickpea 2:1 row ratio and this was statistically at par with wheat + chickpea 1:2 but significantly higher than all other treatments.

Aggressivity

Aggressivity value is an important tool to determine the competitive ability of a crop when grown in association with another crop. An aggressivity value of zero indicates that component crops are equally competitive. Both crops have the same numerical value, but the sign of the dominant component is positive and negative sign indicates the dominated component. The highest value of aggressivity of wheat (0.92) was recorded in wheat + chickpea 1:2 row ratio followed by (0.75) in wheat + chickpea 1:1, (0.59) in wheat + chickpea 2:2 and minimum (0.50) in wheat + chickpea 2:1 (Table 1). Similar trend of aggressivity with negative value was recorded in chickpea in different wheat + chickpea row ratio.Megawer *et al.*(2010) reported highest CR value in barley + chickpea (2:1) intercropping system.

Competitive ratio

Competitive ratio is an important way to know the degree with which one crop competes with another crop. Higher CR value for wheat than those for chickpea indicating that wheat was more competitive than chickpea when grown in association with each other. The highest value of competitive ratio of wheat (2.03) recorded in wheat + chickpea 1:2 row ratio followed by (1.95) in wheat + chickpea 1:1, (1.67) in wheat + chickpea 2:2 and minimum (1.54) in wheat + chickpea 2:1. In all the treatments, wheat dominated the chickpea in wheat + chickpea intercropping system. In chickpea highest value of competitive ratio (0.639) was recorded in wheat + chickpea 2:1 row ratio followed by (0.598) in wheat + chickpea 2:2, (0.511) in wheat + chickpea 1:1 and minimum (0.490) in wheat + chickpea 1:2 row ratio (Table 1).The results corroborated the findings of Das *et al.*(2012), who revealed that the legumes, lentil and chickpea were dominated by wheat, irrespective of the planting configurations.

Economics

Gross returns

In methods of sowing the significant higher value gross returns (Rs. 127262 ha^{-1}) was recorded in happy seeder than (Rs. 120342 ha^{-1}) in rotavator. Wheat + chickpea intercropping system influenced the gross returns. All the wheat + chickpea row ratios recorded higher gross returns as compared to sole cropping of chickpea and wheat. Maximum gross returns (Rs.142889 ha^{-1}) were recorded in wheat + chickpea (2:1) row ratio and it was significantly higher than all other intercropping system (Table 2). The results corroborated the findings of Singh *et al.* (2017) and Singh and Aulakh (2015),who reported that gross returns were significantly higher in wheat + chickpea intercropping system than sole cropping.

Net returns

Significantly higher net returns of Rs. 91177 ha^{-1} was recorded in happy seeder than (Rs. 81796 ha^{-1}) in rotavator. Similar result was also found by Gautam *et al.* (2020), in which they recorded higher net returns (Rs. 81998 ha^{-1}) in happy seeder than (Rs. 81228 ha^{-1}) in incorporation (MB plough + disc harrow + rotavator) sowing technologies. Net returns from different wheat + chickpea intercropping systems were worked out to evaluate the profitability of different combinations of wheat + chickpea row ratios. The data presented in Table 2 revealed that all the wheat + chickpea row ratios recorded higher net returns as compared to sole cropping of chickpea and wheat. Maximum net returns (Rs. 105694 ha^{-1}) were recorded in wheat + chickpea (2:1) row ratio and it was significantly higher than all other intercropping systems. The results corroborated with the findings of Kaushik *et al.* (2018), who reported that net returns were significantly higher in wheat + chickpea intercropping system than sole cropping.

Benefit: cost ratio

In methods of sowing happy seeder recorded the significantly higher benefit: cost ratio (3.52) than rotavator (3.12). The results are supported with findings of Gautam *et al.* (2020), who found the higher benefit: cost ratio in happy seeder (2.52) than incorporation (MB plough + disc harrow

+ rotavator) (2.32) sowing technologies. Benefit: cost ratio varied among different wheat + chickpea intercropping systems (Table 2). All wheat + chickpea row ratio recorded higher benefit: cost ratio than sole wheat and sole chickpea.Highest benefit: cost ratio (3.85) was recorded in wheat + chickpea (2:1) row ratio and it was significantly higher than all other cropping system. The similar results were also reported by Kaushik *et al.* (2018), Meena and Kumar(2017) and Dhakad *et al.*(2005), who reported that benefit: cost ratio was significantly higher in wheat + chickpea intercropping system than sole cropping.

The findings of this study indicated that happy seeder was economically best than rotavator method of sowing. Significantly higher gross returns, net returns and benefit: cost ratio was recorded in happy seeder than rotavator method of sowing. Chickpea can successfully grow as intercrop in wheat with happy seeder and rotavator methods of sowing. In intercropping system higher wheat equivalent yield, land equivalent ratio, area time equivalent ratio was recorded in wheat + chickpea (2:1) row ratio. Chickpea improve the wheat yield in intercropping system. Wheat + chickpea (2:1) row ratio gave significantly higher gross returns, net returns, benefit: cost ratio than all other intercropping system

Table 1. Effect of sowing methods and intercropping system on the wheat yield, chickpea yield, wheat equivalent yield (WEY), land equivalent ratio (LER), area time equivalent ratio (ATER), aggressivityvalue and competitive ratio (CR)

Treatments	Wheat grain yield (qha^{-1})	Chickpea grain yield (qha^{-1})	WEY (qha^{-1})	LER	ATER	Aggressivity		Competitive ratio	
						Wheat	Chickpea	Wheat	Chickpea
Methods of sowing									
Happy seeder	40.09	10.01	54.80	1.14	1.12	-	-	-	-
Rotavator	38.49	9.18	52.50	1.13	1.13	-	-	-	-
SD (m)±	0.60	0.31	0.83	00	00	-	-	-	-
CD (p=0.05)	-	-	-	-	-	-	-	-	-
Intercropping system									
Sole wheat	48.10	-	48.10	1.0	1.0	-	-	-	-
Sole chickpea	-	17.44	45.91	1.0	1.0	-	-	-	-
1:1 (wheat+chickpea)	37.47	6.92	55.32	1.17	1.13	0.75	-0.75	1.95	0.511
1:2 (wheat+chickpea)	29.2	10.60	56.59	1.21	1.20	0.92	-0.92	2.03	0.490
2:1 (wheat+chickpea)	45.97	5.29	60.36	1.25	1.21	0.50	-0.50	1.54	0.639
2:2 (wheat+chickpea)	35.72	7.73	55.66	1.18	1.16	0.59	-0.59	1.67	0.598
SD (m)±	1.67	0.83	1.50	0.01	0.01	-	-	-	-
CD (p=0.05)	5.0	2.5	4.5	0.03	0.03	-	-	-	-

Table 2. Effect of sowing methods and intercropping system on cost of cultivation, gross returns, net returns and benefit: cost ratio

Treatments	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
Methods of sowing				
Happy seeder	36079	127262	91177	3.52
Rotavator	38569	120342	81796	3.12
SD (m)±	-	1025.38	1001.32	0.036
CD (p=0.05)	-	3065.91	2993.96	0.11
Intercropping system				
Sole wheat	40031	121481	81450	3.03
Sole chickpea	32485	88944	56544	2.74
1:1 (wheat+chickpea)	39118	130230	91112	3.33
1:2 (wheat+chickpea)	36138	128893	92755	3.57
2:1 (wheat+chickpea)	37195	142889	105694	3.85
2:2 (wheat+chickpea)	39010	130374	91364	3.34
SD (m)±	-	3943.56	3941.46	0.10
CD (p=0.05)	-	11791.25	11784.97	0.32

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