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Growth indices, nutrient uptake and productivity of wheat + chickpea as influenced by soil moisture regimes and sources of nutrients

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ABSTRACT

A field experiment was conducted during 2012–13 and 2013–14 to study the effect of different soil moisture regimes and sources of nutrients on growth indices i.e. plant height, dry matter accumulation, absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR) and nutrient uptake of wheat + chickpea intercropping system on a silty clay loam soil of Palampur. Results of the study showed that irrigated condition increased the growth indices and nutrient uptake of wheat and chickpea over rainfed condition. Integrated nutrient management (INM) recorded the highest growth indices and nutrient uptake of wheat. However, in chickpea, organic nutrient management being statistically at par with INM resulted in higher growth indices and nutrient uptake. The best agronomic practices for higher productivity of wheat + chickpea intercropping system were irrigated condition and INM.

Keywords: Chickpea, INM, inorganic, irrigated, intercropping, organic, rainfed and wheat

Intercropping, the growing of more than one species simultaneously in the same field is a cropping strategy, which causes more stable yields, often results in a more efficient utilization of resources; and a method to reduce problems with weeds, minimize nitrogen losses and reduce plant pathogens pressure. To accomplish this, efficient, productive and economically viable systems has to be selected and under such circumstances, cereal-legume intercropping systems play significant role for efficient utilization of resources. The main theme of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labour. Intercropping of chickpea in wheat has gained interest because of potential advantage it offers to the crops *i.e.* improved utilization of growth resources by the crops and hence, increased productivity. Although chickpea fixes nitrogen from atmosphere, there is strong evidence that nitrogen fertilizer increases seed yield, those of seed protein and amino acids. However, its requirements for nitrogen fertilizers are lower than those of other crops to obtain higher yield and improved seed quality (Dhima *et al*., 2015). Intercropping mainly with legumes improves the soil fertility both in rainfed and irrigated conditions by fixing atmospheric nitrogen.

Inorganic sources of nutrients have played a prominent role in increasing food grain production of the country in the past and going to be crucial input in future as well. Balanced and adequate use of fertilizers helps to maintain good soil health which is essential for agriculture production and national economy. At the same time, organic farming is becoming important in the agriculture sector in India, largely through the efforts of small groups of farmers. Organic manures supply all the essential elements necessary for growth though in equal proportion, and are readily decomposed by soil microorganisms. Under such conditions an integrated approach is suggested through complementary use of inorganic and organic to boost and sustain soil fertility and crop productivity. Although sole application of some organic sources of nutrients to crops was found beneficial, however, complementary use of organic and inorganic fertilizers for crop production seems more productive and sustainable. Therefore, an experiment was devised to study the response of wheat + chickpea intercropping system to organic and inorganic sources of nutrients.

MATERIALS AND METHODS

The field experiment was conducted during winter (*Rabi*) seasons of 2012-13 and 2013-14 at Model Organic Farm, Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at 32°.4 N latitude and 76°.3 E longitudes at an elevation of about 1224 meters above mean sea level. Experimental site was silty clay loam soil in texture, acidic in reaction, high in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium. The experiment was laid out in split plot design with irrigation treatments in main plot and nutrient management in sub plot using three replications. The experiment consisted of 8 treatments comprising of two irrigation treatments *i.e.* irrigated and rainfed in main plots and combinations of four nutrient management practices *i.e.* organic (soil treatment with jeevamrit + seed treatment with *Azospirillum* / *Rhizobium* and PSB + vermicompost @ 10 t ha^{-1} having moisture content 25% + 3 sprays of vermiwash), inorganic (recommended

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NPK), integrated (5 tonnes VC + 50% of recommended NPK) and farmer's practice (2.5 tonnes VC + 25% of recommended NPK) in sub plots. The present experiment was conducted in permanent plots of Paddy - Wheat + Chickpea cropping system since *Kharif* 2012. Wheat 'HPW–155' and chickpea 'Himachal Chana–1' were sown on 27th & 28th October during 1st and 2nd year, respectively. Wheat and chickpea were sown in the ratio of 1:1 and the row spacing was 25 cm between two crops. Seed rate of 50 kg ha^{-1} for wheat and 20 kg ha^{-1} for chickpea was used. The recommended dose of NPK used in wheat crop was N: P_2O_5 : K_2O 80 : 40 : 40 kg ha^{-1} in rainfed condition and N : P_2O_5 : K_2O 120 : 60 : 40 kg ha^{-1} in irrigated condition, respectively. Half dose of nitrogen and whole P_2O_5 and K_2O were incorporated in soil, as per the treatments, as basal dose and remaining half dose of nitrogen was top dressed at tillering stage of the wheat crop. No additional dose of fertilizer was added to chickpea crop. Nutrient content of vermicompost used was 1.5% N, 1.0% P and 0.6% K. The quantity of nutrients added in different management practices was N : P_2O_5 : K_2O 113 : 75 : 45 kg ha^{-1} in organic , N : P_2O_5 : K_2O 80 : 40 : 40 kg ha^{-1} (rainfed) and N : P_2O_5 : K_2O 120 : 60 : 40 kg ha^{-1} (irrigated) in inorganic, N : P_2O_5 : K_2O 56 : 38 : 23 kg ha^{-1} + N : P_2O_5 : K_2O 80 : 40 : 40 kg ha^{-1} (rainfed) and N : P_2O_5 : K_2O 120 : 60 : 40 kg ha^{-1} (irrigated) in integrated and N : P_2O_5 : K_2O 28 : 19 : 11 kg ha^{-1} + N : P_2O_5 : K_2O 80 : 40 : 40 kg ha^{-1} (rainfed) and N : P_2O_5 : K_2O 120 : 60 : 40 kg ha^{-1} (irrigated) in famer's practice. Jeevamrit is a solution prepared by using cow urine 1 L, cow dung 1 kg, jaggery 200 g, gram flour 200 g, fertile soil 100 g and 20 L water with proper stirring and kept for 20 days prior to its application. Foliar application of vermiwash was done at tillering, jointing and ear formation stages of wheat. Two hand weeding were done for weed management at 25 and 78 days after sowing (DAS) during 1st year and at 29 and 84 DAS during 2nd year. After pre sowing irrigation, crop was irrigated twice with flood irrigation at 20 and 181 DAS during 1st year and at 23 and 177 DAS during 2nd year. The meteorological data during the crop season revealed that the weekly maximum and minimum temperature ranged from 13.0 to 30.4^{o}C and 2.6 to 17.7^{o}C, respectively. The average relative humidity ranged between 41.5 to 76.5 per cent. The mean weekly sunshine hours ranged from 2.5 to 10.8 hours during the growing season. Rainfall received during crop period was 483.8 and 569.4 mm during 1st and 2nd year of experiment. The plant samples were collected at harvest and analysed for N, P and K content in grain and straw. The total nutrient uptake by crop was worked out by multiplying nutrient content in grain and straw with their respective biomass and summing uptake values of grain and straw. Since data followed the homogeneity test, pooling was done over the seasons and mean data were presented. Different crop indices were calculated by following formulae:

$$\text{Absolute growth rate (AGR)} = \frac{h_2 - h_1}{t_2 - t_1} = \text{cm day}^{-1}$$

Where, h_1 and h_2 are the plant height at t_1 and t_2 times, respectively.

$$\text{Crop growth rate (CGR)} = \frac{w_2 - w_1}{t_2 - t_1} = \text{g m}^{-2}\text{ day}^{-1}$$

Where, w_1 and w_2 are whole plant dry weight at t_1 and t_2 time, respectively.

Relative growth rate

$$\text{(RGR)} = \frac{(\log_e w_2 - \log_e w_1)}{t_2 - t_1} = \text{g g}^{-1}\text{ day}^{-1}$$

Where, w_1 and w_2 are dry weight of whole plant at times t_1 and t_2, respectively.

$$\text{Productivity} = \frac{\text{Grain yield}}{\text{Duration of crop}} = \text{kg ha}^{-1}\text{ day}^{-1}$$

RESULTS AND DISCUSSION

Growth indices

Plant height and dry matter accumulation of wheat

The plant height was significantly influenced by irrigated condition over rainfed condition after 90 DAS. It might be due to sufficient availability of moisture in root zone and better utilization of plant nutrients by wheat. Among nutrient management treatments, application of integrated nutrient management (INM) being statistically at par with inorganic nutrient management but produced taller plants as compared to farmer's practice at 150 DAS. Singh *et al.* (2011) also reported that combined application of organic and inorganic nutrients increased the plant height of wheat.

Irrespective of treatments, there was a gradual increase in dry matter production up to harvest as presented in table 1. Dry matter accumulation was significantly increased with irrigated condition as compared to rainfed condition at 90, 150 DAS and at harvest. It might be due to the fact that sufficient soil moisture for continued growth was maintained by providing irrigation which led to higher photosynthetic assimilation, as a result plant growth improved and led to higher accumulation of dry matter. Among nutrient management methods, INM significantly increased dry matter accumulation over organic nutrient management and farmer's practice, but it remained statistically at par with inorganic nutrient management at all stages. These

Table 1: Effect of treatments on plant height and dry matter accumulation of wheat (pooled of 2 years)

Treatment	Plant height (cm)				Dry matter accumulation (g m^{-2})			
	30 DAS	90 DAS	150 DAS	Harvest	30 DAS	90 DAS	150 DAS	Harvest
Soil moisture regime								
Rainfed	10.0	28.1	88.5	89.4	16.9	104.1	307.4	598.1
Irrigated	10.5	32.5	96.3	97.8	19.1	108.7	313.6	612.9
SEm (±)	**0.4**	**0.5**	**1.8**	**1.7**	**0.7**	**1.0**	**1.4**	**3.3**
LSD (0.05)	**NS**	**2.1**	**7.6**	**7.3**	**NS**	**4.3**	**6.1**	**14.1**
Nutrient management								
Organic	10.2	29.1	90.0	91.8	17.1	104.6	307.2	601.2
Inorganic	10.2	31.3	94.7	95.4	19.2	107.5	312.5	609.9
Integrated	11.2	33.2	98.3	99.5	20.7	113.4	322.8	621.2
Farmer's practice	9.4	27.4	86.5	87.8	15.2	100.2	299.5	589.9
SEm (±)	**0.9**	**2.9**	**4.9**	**5.0**	**1.6**	**4.2**	**6.2**	**9.6**
LSD (0.05)	**NS**	**NS**	**8.1**	**NS**	**2.5**	**7.3**	**10.7**	**16.1**

Table 2: Effect of treatments on plant height and dry matter accumulation of chickpea (pooled of 2 years)

Treatment	Plant height (cm)				Dry matter accumulation (g m^{-2})			
	30 DAS	90 DAS	150 DAS	Harvest	30 DAS	90 DAS	150 DAS	Harvest
Soil moisture regime								
Rainfed	5.2	13.4	47.6	61.6	3.3	16.9	54.8	104.9
Irrigated	5.4	14.6	53.3	66.5	3.6	19.3	59.2	115.8
SEm (±)	**0.2**	**0.3**	**1.3**	**3.3**	**0.2**	**0.5**	**1.0**	**2.2**
LSD (0.05)	**NS**	**1.2**	**5.5**	**NS**	**NS**	**2.0**	**4.4**	**9.4**
Nutrient management								
Organic	5.8	16.3	57.2	70.6	3.9	20.7	64.8	121.4
Inorganic	4.9	12.7	48.6	62.2	3.3	17.4	55.4	109.6
Integrated	5.5	15.1	54.7	66.8	3.6	18.6	58.3	113.5
Farmer's practice	5.0	11.8	41.2	56.5	3.0	15.5	49.7	97.0
SEm (±)	**0.5**	**0.9**	**3.6**	**7.1**	**0.4**	**1.3**	**3.5**	**6.6**
LSD (0.05)	**NS**	**1.6**	**5.9**	**NS**	**NS**	**2.1**	**6.0**	**10.9**

results are in accordance with those of Singh *et al.* (2011) who had reported that combined application of organic manures and inorganic fertilizers in wheat increased the dry matter accumulation. It might be due to the fact that enhanced availability of nutrients helped in increasing leaf area resulting in higher photo-assimilates and there by resulted in more dry matter production.

Plant height and dry matter accumulation of chickpea

Plant height was significantly higher in irrigated condition as compared to rainfed condition at 90 and 150 DAS. It might be due to the presence of sufficient moisture in the root zone which increased the availability of N, P and K to gram plant. The effect of different nutrient management practices on plant height was significant at 90 and 150 DAS. Organic nutrient management being statistically at par with INM resulted in significantly higher plant height as compared to farmer's practice at 90 and 150 DAS. However, at 90 DAS difference in plant height due to inorganic and farmer's practice was not significant, whereas at 150 DAS, plant height of gram was significantly lowest in farmer's practice. Singh and Sharma (2011) also reported that organic nutrient management increased the plant height of gram. Increase in plant height could be attributed to the higher production of plant growth promoting factors by beneficial microbial inoculants present in organic manures which might have resulted in more intense root system and increased shoot growth by enhanced nutrient uptake.

Table 3: Effect of treatments on AGR, CGR and RGR of wheat (pooled of 2 years)

Treatment	AGR (cm day^{-1})				CGR (g m^{-2} day^{-1})				RGR (g $g^{-1}day^{-1}$)			
	30 DAS	**90 DAS**	**150 DAS**	**Harvest**	**30 DAS**	**90 DAS**	**150 DAS**	**Harvest**	**30 DAS**	**90 DAS**	**150 DAS**	**Harvest**
Soil moisture regime												
Rainfed	0.33	0.30	1.01	0.02	0.57	1.45	3.39	4.84	0.041	0.032	0.038	0.0411
Irrigated	0.35	0.37	1.06	0.02	0.64	1.49	3.41	4.99	0.043	0.033	0.039	0.0413
SEm (±)	**0.01**	**0.02**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.03**	**0.001**	**0.0001**	**0.0002**	**0.0001**
LSD (0.05)	**NS**	**0.06**	**0.02**	**NS**	**0.06**	**0.03**	**NS**	**0.09**	**NS**	**NS**	**NS**	**0.0002**
Nutrient management												
Organic	0.34	0.32	1.02	0.03	0.57	1.46	3.38	4.90	0.041	0.032	0.038	0.0411
Inorganic	0.34	0.35	1.06	0.01	0.64	1.47	3.42	4.96	0.043	0.032	0.039	0.0412
Integrated	0.37	0.37	1.08	0.02	0.69	1.54	3.49	4.97	0.044	0.033	0.039	0.0412
Farmer's practice	0.31	0.30	0.99	0.02	0.51	1.42	3.32	4.84	0.039	0.032	0.038	0.0411
SEm (±)	**0.03**	**0.01**	**0.09**	**0.01**	**0.03**	**0.02**	**0.06**	**0.09**	**0.001**	**0.0004**	**0.0001**	**0.0001**
LSD (0.05)	**NS**	**0.04**	**0.02**	**NS**	**0.08**	**0.07**	**0.11**	**NS**	**0.002**	**NS**	**0.0002**	**NS**

Table 4: Effect of treatments on AGR, CGR and RGR of chickpea (pooled of 2 years)

Treatment	AGR (cm day^{-1})				CGR (g m^{-2} day^{-1})				RGR (g $g^{-1}day^{-1}$)			
	30 DAS	**90 DAS**	**150 DAS**	**Harvest**	**30 DAS**	**90 DAS**	**150 DAS**	**Harvest**	**30 DAS**	**90 DAS**	**150 DAS**	**Harvest**
Soil moisture regime												
Rainfed	0.17	0.14	0.57	0.23	0.11	0.23	0.63	0.83	0.017	0.019	0.026	0.028
Irrigated	0.18	0.15	0.64	0.22	0.12	0.26	0.67	0.94	0.018	0.020	0.027	0.029
SEm (±)	**0.01**	**0.01**	**0.02**	**0.08**	**0.01**	**0.01**	**0.01**	**0.03**	**0.001**	**0.0002**	**0.0001**	**0.0003**
LSD (0.05)	**NS**	**NS**	**0.03**	**NS**	**NS**	**0.03**	**0.02**	**0.09**	**NS**	**0.001**	**NS**	**0.001**
Nutrient management												
Organic	0.19	0.18	0.68	0.22	0.13	0.28	0.73	0.94	0.020	0.020	0.027	0.029
Inorganic	0.16	0.13	0.60	0.23	0.11	0.24	0.63	0.90	0.017	0.019	0.026	0.029
Integrated	0.18	0.16	0.66	0.20	0.12	0.25	0.66	0.92	0.018	0.020	0.027	0.029
Farmer's practice	0.17	0.11	0.49	0.25	0.10	0.21	0.57	0.79	0.016	0.018	0.026	0.028
SEm (±)	**0.02**	**0.02**	**0.07**	**0.14**	**0.01**	**0.02**	**0.06**	**0.05**	**0.002**	**0.0008**	**0.001**	**0.0004**
LSD (0.05)	**NS**	**0.05**	**0.11**	**NS**	**0.02**	**0.04**	**0.11**	**0.09**	**0.003**	**0.001**	**NS**	**0.001**

Table 5: Effect of treatments on nutrient uptake of wheat and chickpea (pooled of 2 years)

Treatment	Nutrient uptake (kg ha^{-1})					
	Wheat			Gram		
	N	P	K	N	P	K
Soil moisture regime						
Rainfed	48.22	8.93	31.56	11.44	1.35	5.81
Irrigated	56.76	10.75	35.86	14.97	1.99	7.37
SEm (±)	**0.77**	**0.15**	**0.39**	**0.17**	**0.04**	**0.11**
LSD (0.05)	**2.31**	**0.46**	**1.16**	**1.51**	**0.12**	**1.34**
Nutrient management						
Organic	53.76	10.09	34.28	17.16	2.29	8.56
Inorganic	56.67	10.47	36.39	11.39	1.46	5.61
Integrated	61.17	11.51	39.48	14.46	2.00	7.20
Farmer's practice	39.36	7.44	26.19	9.90	1.12	4.97
SEm (±)	**1.22**	**0.24**	**0.61**	**0.91**	**0.10**	**0.47**
LSD (0.05)	**3.65**	**0.73**	**1.83**	**2.74**	**0.31**	**1.40**

Irrespective of treatments, there was a gradual increase in dry matter production up to harvest as evident from table 2. Dry matter accumulation was significantly higher with irrigated condition as compared to rainfed condition at 90, 150 DAS and at harvest. Organic nutrient management recorded higher dry matter accumulation as compared to farmer's practice, but it remained statistically at par with INM at 90 DAS and at harvest. Jat and Ahlawat (2004) reported that application of vermicompost resulted in higher dry matter accumulation. It might be due to the fact that vermicompost contain all the essential plant nutrients and give steady supply of these nutrients during entire crop period, which ultimately increases the dry matter accumulation of plants.

AGR, CGR and RGR of wheat and chickpea

CGR is regarded as the most meaningful growth function since it represents the net results of photosynthesis, respiration and canopy area interaction. CGR is also a representative of the most common agronomic measurements such as yield of dry matter per unit land area. RGR shows the amount of dry matter production with respect to the unit weight of the current dry matter of a plant over time. AGR, CGR and RGR of wheat and chickpea increased with irrigated condition at all growth stages than rainfed condition which might be due to the fact that moisture availability for longer periods resulting in balanced nutrient absorption. Among nutrient management, INM resulted in higher AGR, CGR and RGR of wheat. However, it was statistically at par with inorganic nutrient management in case of CGR and RGR. Since AGR is directly related to plant height so more plant height in INM resulted in higher AGR. Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light interception.

Nutrient management practices influenced CGR in chickpea due to the better nutritional environment for plant growth at active vegetative stage as a result in improvement in root growth which ultimately increased the dry matter and CGR. Organic nutrient management being statistically at par with INM resulted in higher AGR, CGR and RGR of chickpea. Application of organic manure resulted in more availability of nutrients and distribution in different parts of plants, which affects the plant height or development of plant and leads to increase in AGR. AGR was high in the early growth period *i.e.* up to 150 DAS and then declined at the later stages of growth (after 150 DAS) in both wheat and chickpea. The decrease in AGR at the time of harvest is due to senescence of leaves. Namvar *et al.* (2011) reported that inoculation with *Rhizobium* increased CGR at all levels. The increase in CGR of wheat and chickpea with the increasing trend may be due to accelerating the photosynthesis activity and the positive response of CGR to plant population.

Nutrient uptake of wheat and chickpea

As the nutrient uptake values were influenced greatly by the grain and straw yields of the crops, these followed a similar trend. Thus irrigated condition significantly increased the nitrogen, phosphorous and potassium uptake in grains and straw of wheat over rainfed condition because of the reason that the increase in

Table 6: Effect of treatments on yield and productivity of wheat and chickpea (pooled of 2 years)

Treatment	Wheat				Chickpea			
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Productivity (kg ha^{-1}day^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Productivity (kg ha^{-1}day^{-1})
Soil moisture regime								
Rainfed	2325	4911	7236	11.68	276	511	787	1.35
Irrigated	2814	5226	8040	14.14	365	617	982	1.78
SEm (±)	**63**	**103**	**127**	**0.221**	**20**	**25**	**39**	**0.06**
LSD (0.05)	**189**	**308**	**380**	**0.95**	**59**	**74**	**118**	**0.26**
Nutrient management								
Organic	2593	5050	7643	13.03	411	737	1148	2.00
Inorganic	2776	5504	8280	13.95	279	482	761	1.36
Integrated	2854	5672	8526	14.34	343	610	953	1.67
Farmer's practice	2053	4048	6101	10.31	249	428	677	1.22
SEm (±)	**69**	**96**	**163**	**0.62**	**24**	**21**	**32**	**0.17**
LSD (0.05)	**207**	**289**	**489**	**1.04**	**71**	**64**	**95**	**0.28**

supply of irrigation provided adequate moisture in soil, which played an important role in nutrient uptake (Dutta and Mondal, 2006). Among nutrient management, INM recorded significantly higher nitrogen, phosphorous and potassium uptake in grains and straw of wheat as compared to other nutrient management practices. Such results are obvious, as application of fertilizer N in combination with organic manures and biofertilizer is known to improve various physico-chemical properties resulting in enhanced nutrient absorption or uptake. Similar findings were also observed by Singh (2006). Since the uptake of nutrient is a function of dry matter and nutrient content, the higher biological yield resulted into higher N and P uptake.

Significantly higher nitrogen, phosphorous and potassium uptake in grains and straw of chickpea were obtained under irrigated condition over rainfed condition. Among nutrient management, organic nutrient management was statistically at par with INM produced significantly higher nitrogen, phosphorous and potassium uptake in grains and straw of chickpea. It might be due to the better availability of nutrients in the available forms. Thangavel *et al*. (2003) reported the increasing trend in the uptake of nitrogen, phosphorous and potassium due to application of liquid organic manure (vermiwash). Alagawadi and Gaur (1988) reported in experimental study that the inoculation of *Rhizobium* enhances the nitrogenase activity and the phosphate-solubilizer (*Pseudomonas striata*) increased the available phosphorus content of the soil. Combined inoculation of *Rhizobium* and *Pseudomonas striata* increased the nitrogen and phosphorus uptake significantly over the un-inoculated treatment.

Productivity of wheat and chickpea

Significantly higher grain (2814 kg ha^{-1}), straw (5226 kg ha^{-1}) and biological (8040 kg ha^{-1}) yields of wheat were obtained under irrigated condition over rainfed condition. Irrigated condition significantly increased the grain yield of wheat by 21.0 per cent than rainfed condition. Among nutrient management, INM produced significantly higher grain, straw and biological yield of wheat and was statistically at par with inorganic nutrient management. INM produced 2.8, 10.1 and 39.0 per cent higher grain yield over inorganic, organic and farmer's practice, respectively. It might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favourable increase in yield attributing characters which ultimately led towards an increase in economic yield.

Significant increase in seed (365 kg ha^{-1}), straw (617 kg ha^{-1}) and biological yield (982 kg ha^{-1}) of chickpea was recorded in irrigated condition over rainfed. Among nutrient management, higher seed, straw and biological yield were obtained with organic nutrient management as compared to other treatments. However, it was statistically at par with INM in case of seed and straw yield. The increase in yield was 19.8, 47.3 and 65.1per cent over INM, inorganic and farmer's practice, respectively. The increased seed yield in organic condition might be due to better availability of nutrients throughout the crop growth that ultimately improved the growth and yield contributing characters of chickpea and hence resulted in higher seed yield. Similar findings were also observed by Singh *et al*. (2004). The increase in biological yield may be due to significantly higher grain and straw yield.

From this study, it was concluded that irrigated condition and INM in wheat + chickpea intercropping system recorded higher productivity in mid hill region of Himachal Pradesh.

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