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Yield and quality of mustard (*Brassica juncea*) and lentil (*Lens esculenta*) intercropping system influenced by different fertility levels

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Abstract
A field experiment was conducted in Split Plot Design with five intercropping systems [sole mustard, sole lentil, mustard + lentil (1:3), mustard + lentil (2:2) and mustard + lentil (2:3)] and four fertility levels (0, 75, 100 and 125% RDF) and replicated thrice during *rabi* season, 2017-18 at Agronomy farm, S.K.N. College of Agriculture, Jobner. The results revealed that planting of mustard in 2:2 row ratio, being at par to sole mustard, gave significantly higher seed yield (2234 kg/ha) as compared to 1:3 and 2:3 row ratios. The 1:3 row ratio, remaining at par to sole lentil, recorded significantly higher seed yield of lentil as compared to 2:2 and 2:3 row ratio. The 1:3 row ratio, recorded significantly higher nitrogen concentration in seed of mustard. Planting of mustard in 2:2 and planting of lentil in 1:3 row ratio, recorded significantly highest total uptake of nitrogen and phosphorus. Application of fertility levels up to 125% RDF significantly increased the seed yield of mustard and lentil and nitrogen concentration in seed of mustard and straw of lentil, total nitrogen and phosphorus uptake of mustard and lentil. Whereas, RDF up to 100% significantly increased nitrogen concentration in stover and seed of lentil, phosphorus concentration in seed and stover/straw of mustard and lentil, oil content in seed of mustard and protein content in seed of lentil.

Keywords: Mustard, Lentil, Intercropping, RDF, Protein, Oil

1. Introduction
Oilseed crops are main source of energy in the diet of Indians. Though, India has become self-reliant with respect to food grains but still lagging behind in the production of oilseeds. Indian mustard (*Brassica juncea*) is one of the major edible oil seed crop, maximizing mustard production and productivity is crucial for reducing edible oil import burden for the country. While, lentil is the good supplier of protein and has a high nutritional value, its production and productivity enhancement is vital for achieving food and nutritional security. Hence, maximizing the productivity of Indian mustard (*Brassica juncea*) + lentil (*Lens esculenta*) cropping systems is crucial for the country. Intercropping is one of the most important techniques which, involves growing of crops under different plant geometry. To avoid the risk of sole crop failure, adoption of intercropping is more safe and profitable cropping system for increasing the total production and net profit per unit area. Intercropping offers to farmers an opportunity to utilize diverse resources available at his farm (Ghosh, 2004) [7]. Legumes offer excellent compatible combination for mixing with oilseeds to minimize the competition and to confer symbiotic association to achieve the prime aim of maximum use of available resources. The productivity of crop is largely influenced by fertility management. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Exploitation of genetic yield potentiality of new plant types of mustard although depends on the extent of fertilizer application, the balance and compatible composition of all the major nutrients is a must to obtain greater fertilizer use efficiency. Among the commonly applied major nutrients, nitrogen is the key element in mustard production, which is a structural components of protein molecules, amino acids, chlorophyll and other constituents. Its adequate supply promotes higher photosynthesis activity and vigorous vegetative growth. A higher nitrogen supply favours the conversion of carbohydrates into protein.

Phosphorus plays an important role in improving water use efficiency due to its favourable effect on crop growth root development and high seed yield production per unit of water use. Its conspicuous role in hastening crop maturity is of still more interest to us in the age of intensive cropping system.

2. Material and method

The experiment was conducted at Agronomy farm (Plot No. 1-C) S.K.N. College of Agriculture, Jobner (Rajasthan) during *rabi* season 2017-18. The experiment comprising twenty treatment combinations replicated thrice in Split Plot Design (SPD) with five intercropping systems [sole mustard, sole lentil, mustard + lentil (1:3), mustard + lentil (2:2) and mustard + lentil (2:3)] in main plot and four fertility levels (0, 75, 100 and 125% RDF) in sub plot. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), poor in organic carbon (0.14%), low in available nitrogen (130.0 kg/ha) and medium in phosphorus (16.52 kg P_2O_5/ha) and potassium (151.8 kg/ha) content. The seeds of mustard variety T-59 @ 5 kg/ha and Lentil variety RLG-255 @ 40 kg/ha were used for sowing in the experiment. The sowing was done on 09.11.2017. Mustard seeds were sown at a spacing of 45 x 15 cm^2 and lentil was spaced at an intra-row spacing of 10 cm with 30 cm inter-row spacing. In 1:3 row ratio, three rows of lentil was planted after replacing one row of mustard in replacement series. In 2:2 and 2:3 row ratios, two and three rows of lentil were planted in between paired rows of mustard as additive series. Half dose of nitrogen through urea and full dose of phosphorus through DAP were incorporated in the soil before sowing in plots as per treatments and remaining half dose of nitrogen was applied 40 DAS. 60 kg N and 30 kg P_2O_5/ha for mustard sole and 20 kg N and 40 kg P_2O_5/ha for sole crop of lentil were applied. In intercropping systems, the RDF of mustard was applied. Yield of mustard and lentil were computed from the plants of net plot in each treatment. Oil percent in the mustard was determined by Soxhlet apparatus using petroleum ether (60-80ºC) as an extractant and protein content in seed of lentil crop was calculated by multiplying the per cent N content in seed with the factor of 6.25 (A.O.A.C., 1960) [1]..

The uptake of nitrogen by crop was calculated by following formula (Snell and Snell, 1949) [16]:

$$\text{N uptake (kg/ha)} = \frac{\text{Per cent N in seed x Seed yield (kg/ha)} + \text{Per cent N in stover/straw x stover/straw yield (kg/ha)}}{100}$$

The uptake of phosphorus by crop was calculated by following formula (Jackson, 1967) [8]:

$$\text{P uptake (kg/ha)} = \frac{\text{Per cent P in seed x Seed yield (kg/ha)} + \text{Per cent P in stover/straw x stover/straw yield (kg/ha)}}{100}$$

$$\text{Total uptake (kg/ha)} = \frac{\text{Nutrient conc. in seed (\%) x Seed yield (kg/ha)} + \text{Nutrient conc. in stover/straw (\%) x stover/straw yield (kg/ha)}}{100}$$

3. Result and discussion

3.1. Effect of intercropping

3.1.1. Yield

Results indicated that planting of mustard in 2:2 row ratio with lentil obtained significantly highest seed yield (2234 kg/ha) of mustard as compared to 1:3 and 2:3 row ratios, whereas it remained statistically at par with sole planting of mustard. The 2:2 row ratio also improved the seed yield of mustard by 77.2 and 16.1 per cent over 1:3 and 2:3 row ratios, respectively. It may be due to 100% population and beneficial effect of lentil as evidenced by increased growth and yield attributes. These findings are in close conformity with those of Meena *et al.* (2008) [11], Singh *et al*. (2014) [15] and Das *et al*. (2017) [5].

A significant reduction in seed yield of lentil was recorded in 2:2 (739 kg/ha) and 2:3 (980 kg/ha) row ratios as compared to 1:3 (1441 kg/ha) row ratio and 1:3 row ratio remained at par with sole lentil (1400 kg/ha). The reduction in seed yield of lentil in 2:2 and 2:3 row ratios over sole lentil was primarily due to low plant population of lentil in 2:2 row ratio and significant reduction in yield attributes (pods/plant and seeds/pod). This might also be due to adverse effect of mustard as mustard was planted in paired row with 100% population and lentil was added between pair as additive series. Similar results were also found by Yadav *et al*. (2014) [18] and Das *et al*. (2017) [5].

3.1.2. Nutrient concentration, uptake and quality

A significant increase in nitrogen concentration in seed of mustard was recorded in 1:3 row ratio as compared to 2:3 row ratio, sole mustard and 2:2 row ratio. This was probably due to comparatively greater availability of nutrients to mustard in 1:3 row ratio as compared to 2:3 row ratio, sole mustard and 2:2 row ratio. This might be due to complementary effect of intercropping. The results are in close conformity with those of Devi *et al.* (2014) [16]. Among different intercropping systems, the planting of mustard in 2:2 row ratio gave significantly higher total nitrogen and phosphorus uptake as compared to 1:3 and 2:3 row ratio as well as sole crop. Further, sole mustard and 2:3 row ratio also gave significantly higher total nitrogen and phosphorus uptake as compared to 1:3 row ratio.

Similarly, planting of lentil in 1:3 row ratio also gave significantly higher total nitrogen and phosphorus uptake by lentil crop as compared to rest of intercropping treatments and remained at par with sole crop of lentil. Because nutrient uptake is a function of its concentration in crop plant and seed and stover/straw yields of the crop. The results are in close conformity with those of Meena *et al.* (2008) [11] and Abraham and Thenua (2015) [2]. Oil content in seed of mustard and protein content in seed of lentil were not improved significantly by different systems of intercropping.

3.2 Effect of fertility levels

3.2.1. Yield

Application of Increasing levels of fertility up to 125% RDF recorded significant improvement in seed (2129 kg/ha of mustard and 1309 kg/ha of lentil), stover/straw (6428 kg/ha of mustard and 3663 kg/ha of lentil) and biological (8557 kg/ha of mustard and 4972 kg/ha of lentil) yields of mustard and lentil. The increase in seed and stover/straw yields might be due to better nutritional status in the soil, which was low in N and P. The increased supply of NPK and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased growth and yield parameters and ultimately resulted in higher seed and stover/straw yields. The biological yield is a function of seed and stalk yields. Thus, significant increase in biological yield with the application of N and P could be ascribed due to increased seed and stover/stalk yields. The results of present investigation are in line with those of Meena *et al.* (2013) [10], Sharma *et al.* (2013) [14], Singh *et al.* (2014) [15], Balai *et al.* (2017b) [4], and Keerthi *et al.* (2017) [9].

3.2.2. Nutrient concentration, uptake and quality

The significant increase in N concentration in seed of mustard

and straw of lentil and total nitrogen and phosphorus uptake of mustard and lentil were recorded with increased application of RDF up to 125%. The nitrogen concentration in stover of mustard and in seed of lentil, phosphorus concentration in seed and stover/straw, oil content in seed of mustard and protein content in seed of lentil were recorded significantly higher with increased application of 100% RDF over lower levels. This might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N and P in plant parts. Since the nutrient uptake is a function of its content in crop plant and seed and stover/straw yields of the crop. The increase in these parameters due to N and P fertilization led to an increased uptake of nutrients in the present study. Significant increase in protein content and oil percentage because of increased N content in seed which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. These results are in close conformity with the findings of Parihar *et al.* (2009) [13], Trivedi *et al.* (2013) [17], Pandey *et al*. (2016) [12] and Balai *et al*. (2017a) [3].

Table 1: Effect of intercropping system and fertility levels on yields, nitrogen and Phosphorus concentration in seed and stover and total nitrogen and Phosphorus uptake and oil content in seed of mustard

Treatment	Yields (kg/ha)		Nitrogen Concentration (%)		Total nitrogen uptake (kg/ha)	Oil content (%)	Phosphorus concentration (%)		Total phosphorus uptake (kg/ha)
	Seed	Stover	Seed	Stover			Seed	Stover	
A. Intercropping system									
Mustard sole	2050	6214	3.18	0.748	113.01	35.33	0.660	0.256	29.76
Mustard + Lentil (1:3)	1261	3776	3.91	0.787	79.99	37.29	0.700	0.268	19.15
Mustard + Lentil (2:2)	2234	6823	3.58	0.772	134.25	36.64	0.692	0.262	33.70
Mustard + Lentil (2:3)	1924	5795	3.09	0.733	103.06	35.05	0.648	0.253	27.43
SEm±	53	177	0.09	0.019	2.61	0.88	0.017	0.006	0.65
CD (P=0.05)	185	612	0.31	NS	9.02	NS	NS	NS	2.26
B. Fertility level									
Control	1557	4688	2.90	0.648	74.92	32.92	0.573	0.223	19.32
75% RDF	1800	5458	3.33	0.742	99.62	35.73	0.657	0.254	25.62
100% RDF	1983	6035	3.64	0.811	120.14	37.82	0.722	0.278	31.01
125% RDF	2129	6428	3.89	0.839	135.62	37.85	0.748	0.284	34.09
SEm±	36	102	0.06	0.014	2.07	0.60	0.013	0.005	0.54
CD (P=0.05)	118	334	0.21	0.047	6.76	1.97	0.042	0.016	1.75

NS= Non significant

Table 2: Effect of intercropping system and fertility levels on yields, nitrogen and Phosphorus concentration in seed and straw and total nitrogen and Phosphorus uptake and protein content in seed of lentil

Treatment	Yields (kg/ha)		Nitrogen Concentration (%)		Total nitrogen uptake (kg/ha)	Protein content (%)	Phosphorus concentration (%)		Total phosphorus uptake (kg/ha)
	Seed	Straw	Seed	Straw			Seed	Straw	
A. Intercropping system									
Lentil sole	1400	3901	3.51	1.59	112.41	21.94	0.342	0.214	13.31
Mustard + Lentil (1:3)	1441	4021	3.57	1.62	117.89	22.31	0.345	0.218	13.92
Mustard + Lentil (2:2)	739	2060	3.42	1.53	57.43	21.38	0.328	0.209	6.82
Mustard + Lentil (2:3)	980	2730	3.37	1.49	74.53	21.06	0.321	0.203	8.80
SEm±	33	97	0.08	0.04	2.84	0.52	0.008	0.005	0.34
CD (P=0.05)	113	335	NS	NS	9.82	NS	NS	NS	1.18
B. Fertility level									
Control	937	2604	3.11	1.31	63.63	19.44	0.281	0.176	7.26
75% RDF	1097	3054	3.41	1.50	83.71	21.31	0.324	0.205	9.87
100% RDF	1217	3391	3.66	1.65	101.10	22.88	0.357	0.226	12.08
125% RDF	1309	3663	3.69	1.77	113.82	23.06	0.374	0.237	13.65
SEm±	23	68	0.07	0.03	1.91	0.43	0.007	0.004	0.23
CD (P=0.05)	76	221	0.23	0.10	6.24	1.41	0.022	0.014	0.74

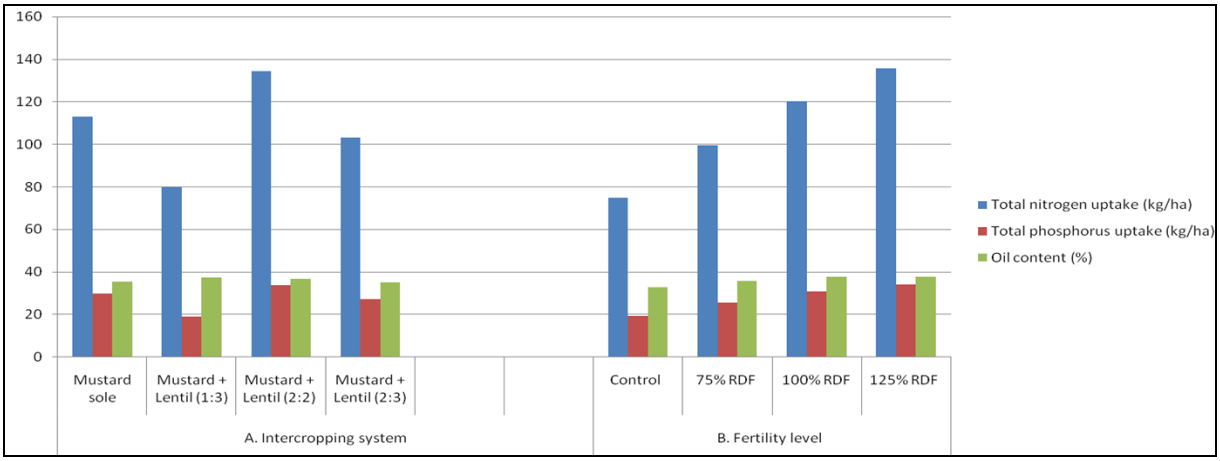

Fig 1: Effect of intercropping system and fertility levels on total nitrogen and phosphorus uptake and oil content in seed of mustard

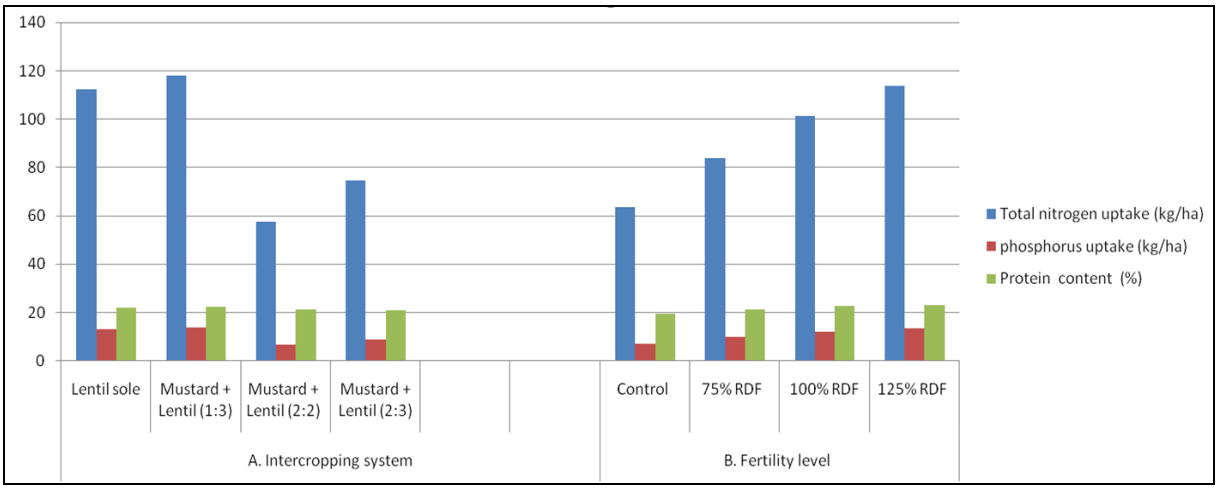

Fig 2: Effect of intercropping system and fertility levels on total nitrogen and phosphorus uptake and protein content in seed of lentil

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