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Evaluation of wheat based mixed cropping in river-basin areas of western Nepal

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Abstract

Growing of oilseeds, rapeseed and winter legumes like lentil, pea and gram as mixed crop with wheat are common practice in Nepal. Field experiment was conducted to find out the optimum seed rate of wheat as well as mixed crops appropriate for wheat based mixed cropping in the region. Field experiment was conducted during the winter seasons of 2010-11 and 2011-12 in the river basin region of Surkhet district in randomized complete block design with three replications. These mixed crops were broadcasted together with wheat at the same time and the same field. Chemical fertilizer was applied at the rate of 100:40:30 kg NPK/ha and no additional fertilizers were supplied to the mixed crops. The sole wheat yielded (4,877 kg/ha) and seed rate combination of lentil or pea (30 %) + wheat (70 %) recorded maximum wheat equivalent yield in these crop combinations. Similarly, seed rate combination of gram (40 %) +wheat (60 %) and toria (20 %) + wheat (80 %) produced higher wheat equivalent yield in respective crop combinations.

Keywords: Cereals, mixed cropping, oilseeds, pulses, seed rate

1. Introduction

Wheat (*Triticum aestivum* L.) is the third most important crop in Nepal, which is cultivated in 754,474 ha with total production of 1,883,147 ton (Anonymous, 2015a). In the hills and the river basin areas, this crop is the second most important cereal crop after maize. Wheat in Nepal is cultivated in a wide range of environments from the Terai (100 m asl) to the high hills (2,500 m asl) as a winter crop (NWRP, 2014). Wheat cropping pattern in Nepal is governed by geographical conditions, production pockets, and the socioeconomic situations as well. So, this crop is cultivated as a sole crop or as a mixed with different crops like mustard/toria, winter legumes like pea, gram, lentil, and crops like linseed (Anonymous, 2015b).

There are many advantages of mixed/intercropping over sole cropping in the context of Nepalese farmers. In sole culture, we grow only one cultivar on a particular field and crop removes soil nutrients from the same level in the soil and draw the same nutrients as the root depth is almost similar (Aziz *et al*., 2015). So, mixed crops would obviously be a good option to manage soil nutrients. Spreading of diseases and insects are also lower in mixed cropping compared to sole culture (Acquaah, 2002). There is disadvantage of mixed crops as well. It cannot be mechanized and should depend on draft and human labor as source of farm energy. However, it is more beneficial to the small-scale farmers like Nepal who grow their crops under rain-fed condition having limited inputs as well as land resources. Wheat in mid hills and river basin areas of Nepal is grown without assured irrigation, so success of main crop depends upon winter rainfall, which is not always sure. So, farmers can harvest at least one crop while wheat is grown together with mixed crops under this insured type of cropping pattern.

The rate of application of chemical fertilizer for wheat is still low due to timely unavailability of the fertilizers, lack of purchasing capacity, limited manpower in the villages, and technical know-how as well (NWRP, 2014). Mixing of different legumes with wheat is a common practice which helps to add nitrogenous fertilizers in the soil (Govind, 2011). Therefore, mixed crops especially legume based, help to enrich the soil. However, minimum technical knowledge and some tricks would be more beneficial to the farmers while cultivating mixed crops (Govind, 2011). There are several factors that farmers should compromise for mixed cropping like fertilizer, seed rate of main crop as well as mixed crops, irrigation, and other intercultural operations (Aziz *et al*., 2015). Seed rate is one of the most important factor to be considered. Till now, the seed rate differs from farmers to farmers and locations to locations so farmers use different seed rate for wheat and mixed crops. Keeping the fact in consideration, we conducted a field experiment with the objectives to identify the optimum seed rate for wheat and mixed crop for wheat based mixed cropping pattern and to estimate the gross income and identify the most beneficial mixed cropping pattern under river basin areas of Surkhet district.

2. Materials and mathods

Field experiment was conducted at the farmer's field of Gumi Village Development Committee (VDC) of Surkhet district during the two consecutive winters of 2010-11 and 2011-12. The experimental site was located at $28^0$29' Northern latitude, $81^0$46' Eastern longitude, and 48`meter altitude (ARS Surkhet, 2014-15).

Soil sample report of the experimental field revealed that organic matter, available nitrogen, phosphorous, and potash were in medium condition. Gumi VDC has warm climate with maximum of 38^0C in the month of June and minimum of 5^0C in the month of January (ARS Surkhet, 2014-15). Detail of the weather data of the year 2010-11 and 2011-12 is presented in figure 1.

2.1 Field trial management : The experiment was laid out in randomized complete block design with three replications for both the years. Regarding the fertilizer management, phosphorous (40 kg/ha) and potash (30 kg/ha) were applied before wheat and other mixed crops sowing on each research plot. For farm yard manure (FYM), all amount was applied before final land preparation. Nitrogen was applied @ 100 kg /ha. 1/3 nitrogen was applied at the time of sowing while remaining nitrogen was applied in two equal splits at first irrigation and second irrigations, respectively. Weeds were removed manually as per need. Wheat seed as well as mixed crops seeds were broadcasted without maintaining any row distances. The research plots were 3-meter long and

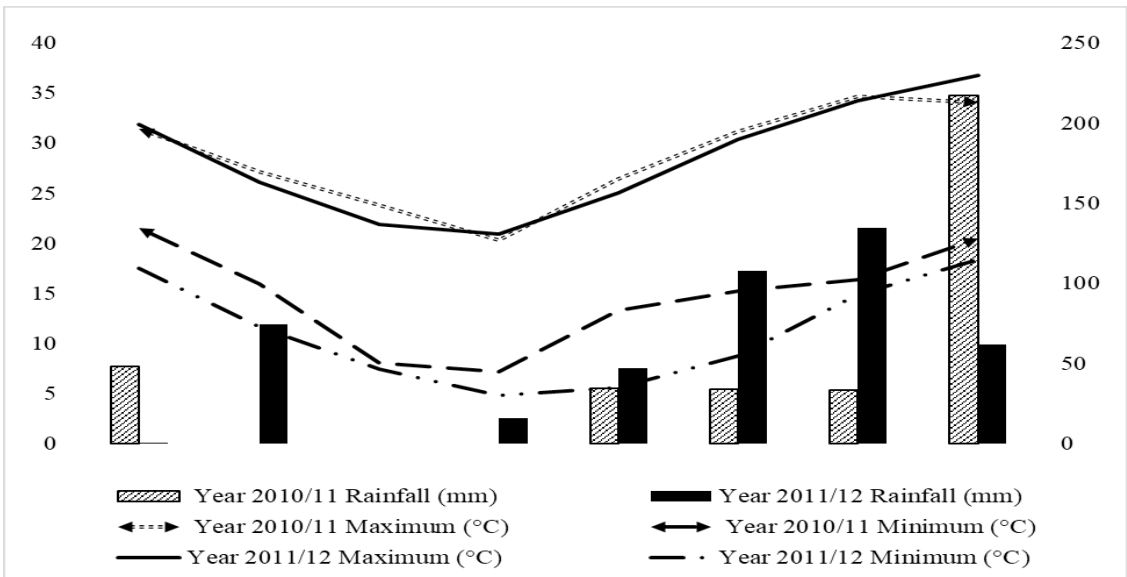

Fig. 1 Weather data of the crop growing period (Source: Regional Weather Department, Birendranagar, Surkhet)

3-meter breadth. The research plots were 3-meter long and 3-meter breadth. Before seed sowing, composite soil samples were taken from the top layers (15 and 30 cm depth) of the experimental field and available N, P, and K were analyzed. Similarly, soil pH and organic matter content were also analyzed at the Soil Science Division, Khumaltar, Lalitpur, Nepal.

2.2 Crop varieties, seed rate, and treatment combinations: Recommended wheat variety WK-1204 was used for the field experiment. Four popular mixed crops in the region i.e. toria (Surkhet local), lentil (Khajura Masuro-1), pea (Sikkim local) and gram (Awarodhi) were selected. These crops and varieties (in the parenthesis) are popularly grown by the farmers in the region (ARS, Surkhet,2015). Recommended seed rate for wheat, toria, lentil, pea and gram in Nepal is 120, 8, 40, 60 and 60 kg/ha, respectively (Anonymous, 2015c). Four different seed rates were made for wheat viz. 120 kg for sole crop, 96 kg/ha (80%), 84 kg/ha (70%), and 72 kg/ha (60%). 3 different seed rates for each toria, lentil, pea, and gram were made by calculating 20%, 30%, and 40% of the recommended seed rate of the respective crops. In this way, altogether 13 different treatments combinations were made as mentioned in the Table 1.

2.3 Calculation of wheat equivalent yield: The wheat equivalent yield was calculated based on total yield of wheat, total yield of intercrops and the market price of wheat and the intercrops. The wheat equivalent yield (WEY) in kg/ha was calculated using the following formula

$$\text{WEY (kg/ha)} = \frac{\text{Yield of wheat x price of wheat) + yield of intercrops x price of intercrops)}}{\text{Price of wheat}}$$

Price of each commodity was estimated based on the nearby markets price. A quick survey was done in the few nearby markets where farmers of the region could go and sell their products and the average price of each commodity was fixed.

3. Results and discussion

Wheat grain yield was significantly ($P<0.001$) influenced by the combination of different seed rates of wheat and mixed crops. The highest wheat yield (4,877 kg/ha) was found with sole wheat culture, followed by the combination of 30% of lentil and 70% of wheat (4,736 kg/ha) and 20% of lentil and 80% of wheat (4,539 kg/ha). The lowest wheat yield (3,294 kg/ha) was recorded in the combination of 40% pea and 60% wheat. Pure culture of wheat produced the highest grain yield and it might be due to sowing of recommended dose of seed i.e. is 120 kg seed/ha that resulted in optimum plant population of the wheat crop. In mixed crop type of combination, lower yield of wheat might be due to lower plant population of wheat and competition for inputs between wheat crop and the mixed crop resulted into lower wheat yield. Similar situation was also described by Acquaah, (2002) and Srivastava *et al.*(2007).

Regarding the seed yield of mixed crops, it differed significantly ($P<0.001$) among the different mixed crop. Highest grain yield (511 kg/ha) was recorded for 30 % pea with 70% wheat. The lowest yield (225 kg/ha) of mixed crop was observed with 20% lentil with 80% wheat. The yield differences were also found among the seed rate of the same mixed crop commodity like toria, lentil, pea, and gram. In most of the cases, 30 % seed of mixed crops performed better rather than 20 or 40 % for all the mixed crops.

This might be due to lower plant population of the mixed crops with only 20 % seed rate. Likewise, there would be denser plant populations of the mixed crops and there might be higher competitions for nutrients and other inputs as in the case described by Singh *et al.*(2014). Regarding the seed yield of mixed crops, it differed significantly ($P<0.001$) among the different mixed crop. Highest grain yield (511 kg/ha) was recorded for 30 % pea with 70% wheat. The lowest yield (225 kg/ha) of mixed crop was observed with 20% lentil with 80% wheat. The yield differences were also found among the seed rate of the same mixed crop commodity like toria, lentil, pea, and gram. In most of the cases, 30 % seed of mixed crops performed better rather than 20 or 40 % for all the mixed crops. This might be due to lower plant population of the mixed crops with only 20 % seed rate. Likewise, there would be denser plant populations of the mixed crops and there might be higher competitions for nutrients and other inputs as in the case described by Singh *et al.*(2014).

Table 1. Average grain yield of wheat, mixed crops, and wheat equivalent yield from mixed cropping season (pooled two years data)

Treatments	Average wheat yield (kg/ha)	Average mixed crop yield (kg/ha)	Wheat equivalent yield (kg/ha)
20% seed of toria + 80% seed of wheat	4400	315	5188
30% seed of toria + 70% seed of wheat	4101	407	5120
40% seed of toria + 60% seed of wheat	3923	397	4915
20% seed of lentil + 80% seed of wheat	4539	225	5214
30% seed of lentil + 70% seed of wheat	4736	340	5757
40% seed of lentil + 60% seed of wheat	4402	366	5498
20% seed of gram + 80% seed of wheat	4427	263	5478
30% seed of gram + 70% seed of wheat	3818	317	5088
40% seed of gram + 60% seed of wheat	4139	310	5379
20% seed of pea + 80% seed of wheat	3620	472	4722
30% seed of pea + 70% seed of wheat	3368	511	4560
40% seed of pea + 60% seed of wheat	3294	422	4279
Wheat sole	4877	0	4877
CV%	13.01	17.04	11.69
F value	**	**	**

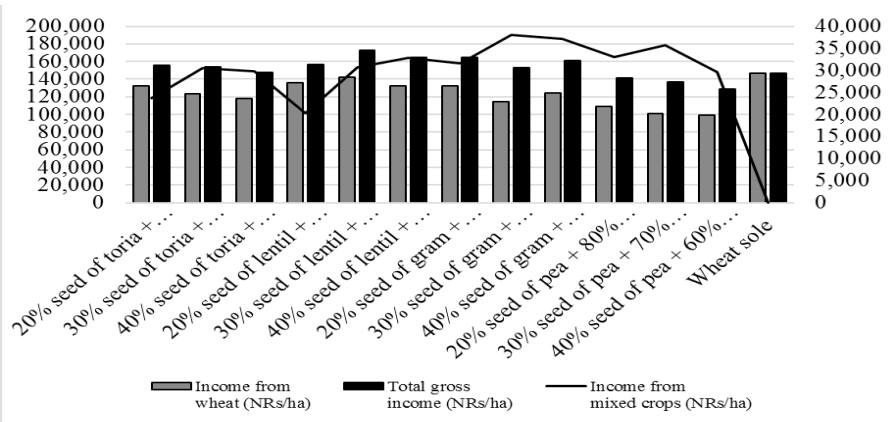

Fig 2. Gross income from wheat and other mixed crops as influenced by different wheat crop based mixed cropping pattern in the river basin areas

Significant higher (P<0.001) wheat equivalent yield was recorded from the combined result of two years' data. Combination between 30 % lentil and 70% wheat yield was found significantly higher with 5757 kg/ha, followed by 40% lentil and 60% wheat seeds (5458 kg/ha). The lowest wheat equivalent yield (4247 kg/ha) was recorded with 40% pea and 60% wheat seed/ha. The higher wheat equivalent yield with lentil was observed in this study probably due to higher/taller plant structure than lentil and gram. Therefore, lower production of wheat as well as pea and mustard was recorded as mentioned earlier due to inter as well as intra competition between the two crops. Similarly, yield attributes of both wheat and the mixed crops/intercrops were affected due to higher competitions as mentioned by Tripathi *et al.*(2016).

The price of wheat and other mixed crops were fixed based on the local market price or farm gate price of the commodities. Total gross income is similar to wheat equivalent yield as it was calculated by adding the price of wheat, price of intercrops, and wheat equivalent yield was estimated. Highest total gross income was record-

ed from the combination between 30% lentil and 70% wheat (Nepalese rupee (NPR) 172,712/ha). The second and third more beneficial combinations were recorded for 40% lentil and 60% wheat (NPR 164,950/ha) and 20% pea and 80% wheat (NPR 164,353/ha). The lowest gross total income was recorded for 40% pea and 60% wheat (NPR 128,382/ha).

Among the intercrops/mixed, the highest income was found with 30% gram (NPR 38,087/ha), followed by 40% gram (NPR 37207/ha) and 40 %peas (NPR 35,783/ha). Due to the higher market price of legumes in Nepal especially lentil and gram, the gross income is also higher of these commodities.

Based on the result of this study, farmers can get more benefit (19%) from the combination of 30% lentil and 70% wheat as compared to pure wheat culture from the wheat based mixed crop practices in the river basin areas. In this study, the quantity of wheat seed rate is reduced up to 30 % and that may fluctuate the wheat yield. Therefore, a separate study with recommended seed rate of wheat with different ratios of intercrops/mixed crops may help to know further details of this type of study.

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