Agronomy Journal of Nepal. **6**(1):180-185
ISSN: 2091-0649 (Print)
DOI: https://doi.org/10.3126/ajn.v6i1.47968

Wheat-based Mixed-cropping Evaluation in the River-basin Areas of Far-western Nepal

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Received: May 28, 2022
Revised: June 25, 2022
Published: July 08, 2022

ABSTRACT

A study was conducted to find-out the optimum seed rate for wheat-based mixed cropping patterns in the research field of the Directorate of Agricultural Research, Bhagetada Doti. The field experiment was conducted in the two consecutive winters of 2019-20 and 2020-21. The recommended seed rate of wheat (120 kg/ha) was considered a check, and the wheat seed rate was reduced by 20, 30, and 40%, respectively, for pea, lentil, and gram, to generate different mixed cropping combinations. The mixed crops were broadcasted together with wheat during wheat sowing time. Chemical fertilizer was applied at the rate of 80:40:30 kg NPK ha^{-1} at the time of seed sowing, and no additional fertilizers were supplied to the mixed crops. The results revealed that the combination of lentils (30%) and wheat (70%) were found to be the most profitable and recorded the maximum wheat equivalent yield followed by the combinations of toria (30%) + wheat (70%) and toria (20%) + wheat (80%) in our study.

Keywords: mid-hills, mixed cropping, oilseeds, pulses, river-basin areas, seed rate

How to cite this article:
Pokharel BB, R Giri, S Mishra, BP Joshi, RB Bhat, H Joshi, DN Joshi, and R Chaudhary. 2022. Wheat-based mixed-cropping evaluation in the river-basin areas of far-west Nepal. Agronomy Journal of Nepal. **6**(1):180-187. DOI: https://doi.org/10.3126/ajn.v6i1.47968

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of Nepal's most important cereal crops, grown on 7,07,000 ha, and the productivity was 3.09 tons/ha (MoAD, 2020). Wheat in Nepal is cultivated in a wide range of environments, from the Terai to the high hills, as a winter crop (NWRP, 2020). After maize, this crop is the most important cereal crop in western Nepal's hilly and river basin regions. Wheat is cultivated as a sole crop or as a mixture with different other crops like mustard/toria, winter legumes like pea, gram, lentil, and linseed.

There are many advantages of mixed and inter-cropping over wheat sole cropping in Nepalese conditions. In monoculture, we grow only one cultivar on a particular field, and the crop removes soil nutrients from the same level in the soil and draws the same nutrients as the root depth is almost similar (Aziz et al 2015). However, the various crops used in mixed cropping have different rooting dimensions, hence exploiting the nutrients and moisture from different soil depths. Therefore, mixed crops would be an excellent option to manage soil nutrients (CGIAR 2020). The spreading of diseases and insects is also lower in mixed cropping compared to sole culture (Acquaah 2002).

It is more significant for small-scale farmers who grow their crops in rain-fed environments with constrained land resources. Because wheat is grown without guaranteed irrigation in Nepal's mid-hills and river basin regions, the success of major crops depends on winter rainfall, which is not always predictable. However, farmers can harvest at least one crop while growing wheat alongside mixed crops using this insured cropping pattern (Waha et al 2020).

The application of chemical fertilizer for wheat is still low because of the timely unavailability of the fertilizers, lack of purchasing capacity, limited human resources in the villages, and technical know-how. Mixing different legumes with wheat is a common practice that helps to add nitrogenous fertilizers to the soil (KC 2008). Mixed crops, particularly those based on legumes, aid soil enrichment. However, farmers who grow mixed crops would profit from having some strategies and little technological know-how (KC 2008). Farmers must compromise on several issues when growing mixed crops, including irrigation, fertilizer, the main crop's seed rate, and other cross-cultural activities (Aziz et al 2015). One of the most crucial things to consider is the seed rate. Till now, the seed rate differs from farmer to farmer and location to location, so farmers use different seed rates for wheat and mixed crops. To address the above problems, a field experiment was conducted with the objective of identifying the optimum seed rate for wheat and companion crops for wheat-based mixed cropping pattern.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted in the research field of the Directorate of Agricultural Research, Sudurpaschim Province, Bhagetada Doti, during the two consecutive winters of 2019-20 and 2020-21. The experimental site was at 29°7' Northern latitude, 80°41' Eastern longitude, and 560-meter from the sea level (DoAR Doti 2021). The temperature in Bhagetada Doti is warm, reaching a high of 42°C in June and a low of 3°C in January (DoAR Doti 2021). Weather parameters have been shown on figure 1.

Field trial management

There were three replications for both the years, and the experiment was set up using a randomized complete block design with 13 treatments. On each plot, nitrogen (80 kg ha^{-1}) in the form of urea, phosphorous (40 kg ha^{-1}) in the form of diammonium phosphate, and potash (30 kg ha^{-1}) in the form of murate of potash were applied before the sowing of wheat and other mixed crops. Before the final field preparation, farm yard manure (FYM) was used at 10 tons ha^{-1}. Whenever necessary, weeds were manually removed. Without maintaining any row distances, wheat and mixed crops seeds were broadcasted evenly in the nine squared meter plot for each treatment combination.

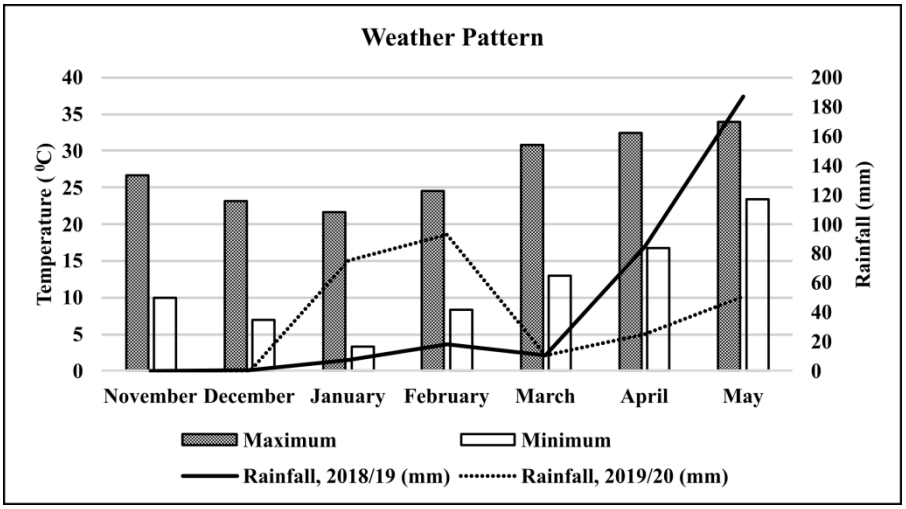

Figure 1. Weather pattern of the experimental site during the crop growing period of 2018/19 and 2019/2020.

Crop varieties and treatment combinations

The recommended wheat variety WK 1204 was used for the study. Four popular mixed crops in the region were chosen, viz toria (farmers' variety), lentil (Khajura Masuro 1), pea (Sikkim local), and gram (Awarodhi). Recommended seed rates of wheat, toria, lentil, pea, and gram seeds are 120, 8, 40, 60, and 60 kg ha^{-1}, respectively (www.narc.gov.np). For each toria, lentil, pea, and gram, 20%, 30%, and 40% of the recommended seed rate were mixed with 80, 70, and 60% of the recommended seed rate of wheat. A detail of the treatment combinations is presented below.

1) 20% recommended seed rate of toria + 80% recommended seed rate of wheat
2) 30% toria + 70% wheat 3) 40% toria + 60% wheat 4) 20% lentil + 80% wheat
5) 30% lentil + 70% wheat 6) 40% lentil + 60% wheat 7) 20% gram + 80%
8) 30% gram + 70% wheat 9) 40% gram + 60% wheat 10) 20% pea + 80% wheat
11) 30% pea + 70% wheat 12) 40% pea + 60% wheat and 13) 100% recommended seed rate of wheat (Wheat sole).

Calculation of wheat equivalent yield

The equivalent wheat yield was calculated based on the total yield of wheat, the total yield of intercrops, and the market price of wheat and intercrops. The equivalent wheat yield (WEY) in kg ha^{-1} was calculated using the following formula.

WEY (kg/ha) = [(Yield of wheat x price of wheat) + (yield of mixed-crop x price of mixed-crop)]/price of wheat

The price of each commodity was estimated based on the nearby markets where farmers of the region could go and sell their products, and the average price of each commodity was fixed.

RESULTS AND DISCUSSION

The interaction of various seed rates of wheat and mixed crops significantly ($p<.001$) influenced grain yield of wheat (Table 1). The sole crop produced the highest grain yield of wheat (4438 kg ha^{-1}), which was followed by mixtures of 30% lentil and 70% wheat (4311.4 kg ha^{-1}) and 20% lentil and 80% wheat (4131 kg ha^{-1}). But 40% pea and 60% wheat produced the lowest wheat yield (2998 kg ha^{-1}). In our study, the sole wheat gave the highest grain yield, which may have resulted from the recommended seeding rate of 120 kg ha^{-1}, which led to an optimal plant population for the wheat crop. In the case of mixed crop combinations, the lower wheat yield may be related to the lower wheat plant population and competitiveness between the wheat crop and the mixed crop for inputs. Both Srivastava et al (2007) and Acquaah (2002) reported a situation comparable to our findings.

Significant differences in the seed yield of companion crops was recorded ($p<0.001$) (Table 1). With 70% wheat and 30% pea, the maximum grain yield of pea was observed compared to other pea seed rate combinations (Table 1). Twenty % lentil and 80% wheat produced the lowest yield of lentil (205 kg ha^{-1}). Additionally, the seed rate of the same mixed crop commodities, such as toriya, lentil, pea, and gram, showed different yields (Table 1). The detail of the research result is presented in table 1.

Table 1. Average wheat grain yield, mixed crop yield, and the equivalent wheat yield were evaluated under the river basin areas of Seti River in western Nepal during the two consecutive winters of 2019 and 2020

SN	Treatments	Average wheat yield (kg ha^{-1})	Average mixed crop yield (kg ha^{-1})	Wheat equivalent yield (kg ha^{-1})
1	20% seed of toria + 80% seed of wheat	4004	287	5078
2	30% seed of toria + 70% seed of wheat	3732	371	5121
3	40% seed of toria + 60% seed of wheat	3569	361	4925
4	20% seed of lentil + 80% seed of wheat	4131	205	4745
5	30% seed of lentil + 70% seed of wheat	4311	309	5238
6	40% seed of lentil + 60% seed of wheat	4006	333	5005
7	20% seed of gram + 80% seed of wheat	4029	239	4747
8	30% seed of gram + 70% seed of wheat	3474	288	4339
9	40% seed of gram + 60% seed of wheat	3766	282	4613
10	20% seed of pea + 80% seed of wheat	3294	429	4587
11	30% seed of pea + 70% seed of wheat	3065	465	4459
12	40% seed of pea + 60% seed of wheat	2998	384	4149
13	Wheat sole	4438	0	4438
CV (%)		13.01	17.04	11.69
F-test		**	**	**

In most of the situations, seed yield from 30% of mixed crops performed better than the 20% or 40% seed rate of the mixed crops (Table 1). This might be due to the lower plant population

with a 20% seed rate, a dense crop population with a 40% seed rate, and there would be more competition with the wheat crop. Similar findings was reportedby Singh et al (2014).

The wheat-equivalent yield was significantly higher ($p<0.001$) from the combined results of the two seasons (Table 1). With 5238 kg ha^{-1}, the yield of 30% lentil and 70% wheat seeds was significantly higher, followed by the combination of 30% toria and 70% wheat seeds (5121 kg ha^{-1}). 40% pea and 60% wheat seed per hectare resulted in the lowest wheat equivalent yield (4149 kg ha^{-1}). This study found a greater wheat equivalent yield with lentils, likely because lentils have shorter plant height and smaller plant structures. As a result, due to inter- and intra-crop competition, wheat with peas produced a lower equivalent wheat yield than expected. This finding agrees with Tripathi et al (2016), who observed increased competition between wheat and mixed crops/intercrops.

Table 2. Income from wheat, mixed crops and wheat equivalent yield evaluated at the Seti river basin area of Bhagetada Doti

Treatments combination	Income_intercrop	Income_wheat	Total_income
20% seed of toria + 80% seed of wheat	42998	160160	203158
30% seed of toria + 70% seed of wheat	55556	149276	204832
40% seed of toria + 60% seed of wheat	54191	142797	196988
20% seed of lentil + 80% seed of wheat	24570	165220	189790
30% seed of lentil + 70% seed of wheat	37128	172390	209518
40% seed of lentil + 60% seed of wheat	39967	160233	200200
20% seed of gram + 80% seed of wheat	28720	161143	189862
30% seed of gram + 70% seed of wheat	34616	138975	173592
40% seed of gram + 60% seed of wheat	33852	150660	184512
20% seed of pea + 80% seed of wheat	51542	131768	183310
30% seed of pea + 70% seed of wheat	55801	122595	178396
40% seed of pea + 60% seed of wheat	46082	119902	165984
Wheat sole	0	177523	177523
CV (%)	13.01	18.76	14.35
F-test	**	**	**

The prices of the wheat and the companion crops were fixed as per the farmgate or local market prices. Since it was derived by adding the price of wheat grain, the price of intercrops, and the predicted wheat equivalent yield, total gross income was comparable to wheat equivalent yield. With 30% lentils and 70%, wheat had the highest gross income of NRs. 2,09,518 ha^{-1} (Table 2). Thirty % tori and 70% wheat (NRs. 2,04,832 ha^{-1}) and 20% pea and 80% wheat (NRs. 2,03,158 ha^{-1}) were the second and third most advantageous combinations. Toria and wheat mixture also gave higher wheat equivalent yield (Table 1), and this might be the higher price of toria in the market. The crops with the lowest gross income were 40% pea and 60% wheat (NRs. 1,75,524 ha^{-1}). Details of the result are presented in Table 2.

CONCLUSIONS

Wheat-based mixed cropping practices in the river basin areas of far-western region can be a significant benefit over pure wheat culture. An additional 20 percent income can be added when wheat is mixed with 30% lentil and 70% wheat. The optimum wheat seed rate needs to be reduced by 30 percent for the maximum benefit, which can also reduce the amount of wheat seed by 30% (36 kg ha^{-1}).

ACKNOWLEDGEMENTS
We sincerely appreciate the staff of the Directorate of Agricultural Research, Bhagetada Doti, for their assistance while conducting field studies and data collection. We acknowledge the Nepal Agricultural Research Council for funding this project.

AUTHORS' CONTRIBUTION
BB Pokharel guided the field experimentation, data collection and analysis and manuscript preparation and the rest others assisted for field experimentation, data collection, entry and manuscript preparation.

CONFLICTS OF INTEREST
The authors have no any conflict of interest to disclose.

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