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ORIGINAL RESEARCH ARTICLE

Effect of sowing methods and varieties on growth and yield of wheat (*Triticum aestivum* L.) in Dang, Nepal

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ABSTRACT

In this study conducted in Gadhawa Rural Municipality, Dang district, from November 2021 to April 2022, the impact of two sowing methods (Line sowing and broadcasting) and four varieties (Bijaya, Gautam, Aditya, and Borlaug 2020) on wheat was investigated. We aimed to identify the best sowing method and variety using a randomized complete block design with three replications. The study focused on various growth and yield parameters, including plant height, tiller number, grain per spike, effective tillers per square meter, thousand grain weight, grain yield per hectare, and biological yield per hectare. Line sowing was found to have the highest impact on biometrical as well as yield attributing characters. More height (111.51 cm), number of tillers (3.80), grain/spike (57.02), and grain yield (3.85 ton/ha) were obtained in line sowing. There was a significant difference observed among the varieties for all the traits except tiller number and biological yield. Borlaug 2020 was found to be superior for performance based on yield attributing traits which have grain/spike, effective tiller/m^2, biological yield, and grain yield of 62.88, 177.15, 6.60 ton/ha, and 3.95 ton/ha respectively. From the interaction effects, variety Borlaug 2020 and line sowing method were found to be superior for cultivation. The study further demonstrates that farmers of Dang can combine Borlaug 2020 with line-sowing methods to obtain promising results.

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INTRODUCTION

Wheat (*Triticum aestivum* L.), a member of the Poaceae and tribe Hordeae is the third important cereal crop in Nepal (Subedi *et al*., 2019; Bhatta *et al*., 2020; Magar *et al*., 2021). Widely known for its nutritional profile containing proteins, vitamins (B5, B1, B6, B3, B8, B2, B12, K, E, and A), calories, and minerals (Kandel *et al*., 2018; Xu *et al*., 2021), wheat commands an average daily consumption of 318 grams (Iqbal, 2022). In Nepal, it is planted in 716978 ha with a total production of 2144568 mt and productivity of 2.99 mt/ha (MoALD, 2023). With regard to trend analysis, MOALD (2022) shows that production is more or less on an increasing trend but there is fluctuation in the area cultivated. The majority of wheat farming takes place in the Terai regions, contributing to 57% of the overall wheat production (MoALD, 2019). Additionally, Terai region experiences heightened urbanization, population growth, and agricultural activities, while the Hill region faces a migration trend (Jaquet *et al*., 2019). This suggests that effective land management is a more pressing concern in the Terai and Hill regions compared to the Mountain region (Timilsina *et al*., 2019). The yield of wheat relies on genetic and external factors. The sowing method chosen by farmers is also a crucial determinant impacting yield (Shtewy and Al-Sharifi 2020). In Nepal, a common sowing method known as broadcasting has been utilized; only progressive farmers and research experts use line sowing (Khatri *et al*., 2019; Hussain *et al*., 2003). Broadcasting involves scattering seeds uniformly across a field without any specific arrangement.

It necessitates a greater quantity of seeds and leads to a reduced number of plants per unit area. Most farmers seem to prefer broadcasting due to its ease of application and cultural preference. Farmers also appear to anticipate lower costs and reduced labor inputs associated with practicing broadcasting. (Alomia-Hinojosa, 2018) In the other hand, line sowing includes maintaining optimum plant population per unit area, optimizes land use, simplifies weed control and maintenance, and facilitates efficient irrigation and pest management leading to higher yield (Ashrafi *et al*., 2009; Hossain *et al*., 2013; Shah *et al*., 2018) Given the critical role of sowing methods in determining agricultural outcomes, understanding which method performs better under specific conditions holds significant practical importance and can enable farmers to make informed decisions, leading to improved resource management, and higher yields. The comparative analysis of two sowing methods accounting for various factors such as soil type, crop type, environmental conditions, and resource availability is lacking. Existing studies often focus on specific aspects or are limited to particular regions, leaving a gap in understanding the broader implications. This research aimed to address this gap by conducting a systematic evaluation of line sowing and broadcasting across (inner terai conditions) Dang, Nepal. We sought to identify the most suitable sowing method.

The selection of location-specific wheat varieties profoundly impacts optimal yields (Pandey *et al*., 2020). These varieties, finely attuned to local soil, climate, and pest conditions, exhibit superior adaptation, enhancing both yield and quality. Utilizing such varieties often reduces input costs, requiring fewer interventions like pesticides and fertilizers due to their natural suitability to prevailing conditions. By choosing wheat varieties that align with the unique characteristics of a given region, farmers can maximize their agricultural output and overall farm profitability. Nepal has introduced approximately 720 different cultivars across 80 different crop species, with 42 of these being specific varieties of wheat that are categorized based on the ecological belts: Mid Hill and High Hills (14), Mid Hills (7), Terai and Hills (5), Terai and Inner Terai (16) (MoALD, 2021). Customized varietal trials are essential in Nepal, as location-specific variety releases are currently uncommon, enabling farmers to choose the most suitable crop varieties for their specific regions. This research focused on assessing the performance of wheat varieties in the environment of Dang (inner Terai region), Nepal, which helped us provide valuable recommendations to farmers on choosing best varieties for maximizing yields and adaptability to local conditions. We chose four varieties for our trial. Among them, two were the traditional, most popular Terai varieties (Garapaty *et al*., 2021), and the other two were gaining popularity among the farmers.

MATERIALS AND METHODS

The study was carried out in a farmers' field in Gadhawa Rural Municipality (27°46'48''N 82°31'48''E), Dang, Nepal during November to April, 2021/22. Geographically, Gadhawa is at the elevation of 195 to 885 masl. Loamy textured soil with uniform fertility status was present in the field that followed a cropping pattern of wheat-fallow-rice sequence for two years (2019 and 2020) before the experiment. The wheat seeds were collected from Nepal Agricultural Research Council (NARC) and the variety used was Bijaya, Gautam, Aditya and Borlaug 2020, the recommended variety of Terai region of Nepal.

Experimental design and treatment factors

The experiment was conducted in double factorized (sowing methods, Varieties) Randomized complete block design with three replications. Different sowing methods (P1: Broadcasting, P2: Line sowing) and varieties (V1: Bijaya, V2: Gautam, V3: Aditya, V4: Borlaug 2020) were combined to form eight treatments.

T1: V1P1 (Bijaya + Broadcasting)
T2: V1P2 (Bijaya + Line Sowing)
T3: V2P1 (Gautam + Broadcasting)
T4: V2P2 (Gautam + Line Sowing)
T5: V3P1 (Aditya + Broadcasting)
T6: V3P2 (Aditya + Line Sowing)
T7: V4P1 (Borlaug 2020 + Broadcasting)
T8: V4P2 ((Borlaug 2020 + Line Sowing)

Each individual plot was 3 m x 2 m, with total of 24 plots. Spacing between replication was 0.5 m and spacing between plots was 0.3 m.

Cultural practices

The land was plowed, harrowed, cleared of weeds and crop residues, and leveled. Well-decomposed Farm Yard Manure was applied in the plots @ 6 tons ha^{-1} two weeks before sowing. Urea, DAP and MOP were applied @ of 120:50:50 kg/ha. Well-spaced rows with a spacing of 25 cm were made, and seeds were sown continuously along these rows in four plots whereas broadcasting were done in the other four plots. Pre-sowing irrigation was followed by additional irrigations at the Crown Root Initiation stage (CRI), tillering stage (45 DAS), and flowering stage (92 DAS). Manual weeding was carried out regularly, tailored to the prevailing weed infestation levels and specific weeding needs. The crop from the net plot area was harvested manually using the sickle at the maturity stage. The biomass yield of the harvested crop was measured, and manual threshing was performed at a designated location. The resulting clean grains were obtained through winnowing and subsequently weighed.

Observations

Five hills were carefully chosen from the interior rows, excluding the border row, specifically for assessing plant height, and the number of tillers at various stages of crop growth. The data for these selected plants were recorded 35 days after sowing, and this measurement process was repeated four more times at regular 20-day intervals. No. of effective tillers m^{-2} were recorded from 1 m^2 area from each plot before harvesting. Total numbers of tillers were counted and were expressed as no. of effective tillers m^{-2}. Thousand randomly selected grains from each plot were weighed to determine thousand grain weight. Biomass yield and grain yield were taken at harvest from the net

plot area. The crop was dried, threshed, sun dried, cleaned and dried further to ensure appropriate moisture level onthe grain. Harvest index was calculated by using following formula.

Biological yield = Grain yield + Straw yield
HI = Economic yield / Biological yield × 100

Statistical analysis

R-Studio and Microsoft Excel were used for data analysis. Microsoft excel were used for entering and organizing data. Analysis of variance (ANOVA) was done by R studio. Duncan's Multiple Range Test (DMRT) was used for separating mean and for comparison between treatments.

RESULTS AND DISCUSSION

Growth attributes

Effect on plant height: Effects of sowing methods and varieties on plant height of different growth stage are shown in Table 1. Showing methods exhibited no disparities in plant height at 35 and 55 days after sowing (DAS), line sowing showed the tallest plants at 75 DAS (88.82 cm) and 95 DAS (111.51 cm), whereas broadcasting resulted in a height of 107.10 cm at 95 DAS. These results highlight the superiority of line sowing in promoting plant height during the later stages of growth. Similar result was obtained from Ullah *et al.* (2018) who reported 8% increase in plant height in line sowing compare to broadcast. Results also matched with the finding of Singh *et al.* (2023), and Khatri *et al.* (2019). Varietal differences significantly impacted plant height throughout the growth stages. At 35 days after sowing (DAS), Borlaug 2020 had the lowest height, while Gautam had the highest, presenting a 4.02 cm disparity. Bijaya, Aditya, and Borlaug 2020 displayed statistically similar heights at this stage. By 55 DAS, Borlaug 2020 had the shortest plants, significantly distinct from the other varieties, while Bijaya, Gautam, and Aditya exhibited similar heights. At 75 DAS, Bijaya reached the maximum height, followed closely by Gautam and Aditya, with an 8.51 cm difference between the tallest and shortest. At 95 DAS, Bijaya, Gautam, and Aditya produced statistically similar heights, while Borlaug 2020 remained the shortest, significantly differing from the rest. These findings showed the variation of wheat varieties on plant height and confirm results from a previous study by Bhattarai *et al.* (2017).

Table 1. Effect of sowing methods and varieties on plant height of wheat.

Plant height (cm)				
Treatments	**35 DAS**	**55 DAS**	**75 DAS**	**95DAS**
Sowing method				
i. Broadcasting	33.28	59.77	86.21^{b}	107.10^{b}
ii. Line sowing	33.45	59.86	88.82^{a}	111.51^{a}
LSD (0.05)	1.8	3.02	1.51	2.91
CV%	6.16	5.76	2.31	3.14
F-test	NS	NS	**	**
Varieties				
i. Bijaya	33.82^{ab}	64.18^{a}	90.83^{a}	113.88^{a}
ii. Gautam	35.53^{a}	62.72^{a}	88.48^{b}	110.41^{a}
iii. Aditya	32.62^{b}	61.50^{a}	88.45^{b}	113.49^{a}
iv. Borlaug 2020	31.51^{b}	50.85^{b}	82.32^{c}	99.42^{b}
LSD (0.05)	2.54	4.27	2.14	4.11
CV%	6.16	5.76	1.98	3.04
Mean	33.37	59.81	86.77	108.88
F-test	*	***	***	***

NS represents non-significant difference among each other at 5% level of significance. DAS=Days after sowing, LSD= Least Significant difference, CV= Coefficient of variation.

Table 2. Effect of sowing methods and varieties on tiller number per plant.

Tiller No. per plant				
Treatments	**35 DAS**	**55 DAS**	**75 DAS**	**95 DAS**
Sowing method				
i. Broadcasting	4.5	5.78	3.75^{b}	2.96^{b}
ii. Line Sowing	4.21	5.61	5.48^{a}	3.80^{a}
LSD (0.05)	0.55	0.97	0.69	0.38
CV%	14.64	19.56	15.82	13.05
F-test	NS	NS	***	***
Varieties				
i. Bijaya	4.37	5.8	4.90	3.73
ii. Gautam	4.57	5.27	4.36	3.1
iii. Aditya	4.6	6.17	4.93	3.23
iv. Borlaug 2020	3.9	5.57	4.26	3.46
LSD (0.05)	0.79	1.38	0.90	0.54
CV%	14.64	19.56	15.82	13.05
Mean	4.36	5.7	4.61	3.38
F-test	NS	NS	NS	NS

NS represents non-significant difference among each other at 5% level of significance. DAS=Days after sowing, LSD= Least Significant difference, CV= Coefficient of variation.

Effect on tiller number: The impact of sowing methods and varieties on tiller count are highlighted in Table 2. Regarding sowing methods, no significant effects were observed at 35 and 55 days after sowing (DAS). However, by 75 DAS, line sowing exhibited a significantly higher tiller count per hill, averaging 5.48 compared to broadcasting's 3.75 tillers per hill. This disparity was found to be statistically significant, indicating a substantial difference between the two sowing methods. This trend persisted at 95 DAS, with line sowing maintaining its superiority, yielding an average of 3.80 tillers per hill, a statistically significant increase over broadcasting. The efficacy of line sowing in tiller production may be attributed to its uniform seed distribution within rows and better management practices. These findings align prior studies by Reda (2014), Khatri *et al.* (2019), and Singh *et al.* (2023), all reporting significant enhancement in tiller numbers with line sowing compared to broadcasting, reaffirming the effectiveness of line sowing in stimulating tiller growth. Across various stages of growth, statistical analysis revealed no significant differences among the examined wheat varieties in this study. At 35 days after sowing (DAS), Aditya exhibited the highest tiller count, averaging 4.6 per hill, while Borlaug 2020 produced the lowest, with an average of 3.9 per hill. However, these differences were found to be non-significant, indicating that there was no statistically significant effect among the varieties at this stage. At 55 DAS, Aditya continued to exhibit the highest tiller count, with an average of 6.17 per hill, whereas Gautam produced the lowest, averaging 5.27 per hill. However, similar to the 35 DAS results, there were no statistically significant differences among the varieties at this stage. No statistically significant effects were observed among the varieties at 75 DAS and 95 DAS. At 95 DAS, Bijaya recorded the maximum number of tillers, with an average of 3.73 per hill, while Gautam had the minimum number of tillers, averaging 3.1 per hill.

Yield and yield attributes

Effective tiller m^{-2}: The average number of effective tillers per square meter was found to be 167.91, and this variable showed a highly significant effect with respect to both sowing methods and varieties (Table 3). When comparing sowing methods, it was observed that line sowing resulted in a significantly higher number of effective tillers per square meter, with an average of 187.50, compared to broadcasting, which yielded 148.32 effective tillers per square meter. This difference was statistically significant, indicating the superior performance of line sowing in terms of effective tiller production. Regarding the varieties, Aditya and Borlaug 2020 exhibited statistically similar numbers of tillers, with 183.55 and 177.15, respectively. These two varieties produced a significantly greater number of tillers compared to Bijaya, which produced 154.80 tillers, and Gautam, which produced 156.15 tillers. In other words, Aditya and Borlaug 2020 outperformed Bijaya and Gautam in terms of tiller production, with statistically significant differences in their favor.

Thousand grain weight: The average thousand grain weight was found to be 46.14 g. Line sowing produced more grain weight (47.87 g) followed by broadcasting (44.40 g), but there was a non-significant difference between the two sowing methods (Table 3). The thousand grain weight value was significantly affected by the varieties. Bijaya, with a weight of 52.26 g, was reported to have the maximum thousand grain weight, followed by Aditya (46.06 g), Gautam (43.40 g), and Borlaug 2020 (42.80 g). Bijaya showed statistically the maximum weight, whereas all other varieties showed a non-significant difference among each other.

Grain yield: An average grain yield of 3.38 tons/ha was observed. Sowing methods showed a significant effect on effective yield (Table 4). Line sowing produced a yield of 3.85 tons/ha, which is statistically different from broadcasting (2.90 tons/ha). These findings corroborate those of Khatri et al. (2019). Variety was found to significantly affect grain yield, with the maximum yield reported in Borlaug 2020 (3.95 tons/ha), followed by Aditya (3.57 tons/ha), Bijaya (3.15 tons/ha), and the least grain yield reported in Gautam (2.86 tons/ha) (Table 4). There was a difference of 1.09 tons/ha between the two extremes.

Table 3. Effect of sowing methods and varieties on yield attributes.

Treatments	Effective tiller /m^2	Grain $spike^{-1}$	Thousand grain wt. (g)
Sowing methods			
i. Broadcasting	148.32^b	42.28^b	44.40
ii. Line sowing	187.50^a	57.02^a	47.87
LSD (0.05)	10.25	5.38	3.96
CV%	7.091	12.37	9.81
F-test	***	***	NS
Varieties			
i. Bijaya	154.80^b	41.27^c	52.26^a
ii. Gautam	156.15^b	39.53^c	43.40^b
iii. Aditya	183.55^a	54.92^b	46.06^b
iv. Borlaug 2020	177.15^a	62.88^a	42.80^b
LSD (0.05)	14.50	7.61	5.61
CV %	7.091	12.37	9.81
Mean	167.91	49.65	46.14
F-test	***	***	*

NS represents non-significant difference among each other at 5% level of significance. DAS=Days after sowing, LSD= Least Significant difference, CV= Coefficient of variation.

Table 4. Effect of sowing methods and varieties on yield character.

	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Sowing methods			
i. Broadcasting	2.90^{b}	6.05	47.93^{b}
ii. Line sowing	3.85^{a}	6.41	60.06^{a}
LSD (0.05)	0.12	1.48	10.08
CV%	4.02	27.16	20.37
F-test	***	NS	*
Varieties			
i. Bijaya	3.15^{c}	6.17	51.05
ii. Gautam	2.86^{d}	5.79	49.39
iii. Aditya	3.57^{b}	6.38	55.95
iv. Borlaug 2020	3.95^{a}	6.60	59.84
LSD (0.05)	0.169	2.10	14.25
CV %	4.025	27.16	20.37
Mean	3.38	6.23	56.515
F-test	***	NS	NS

NS represents non-significant difference among each other at 5% level of significance. DAS=Days after sowing, LSD= Least Significant difference, CV= Coefficient of variation.

Table 5. Interaction effect of sowing methods and varieties on grain yield.

Sowing methods	Varieties	Interaction
Broadcasting	Bijaya	2.96^{e}
	Gautam	1.91^{f}
	Aditya	3.14^{de}
	Borlaug 2020	3.60^{c}
Line sowing	Bijaya	3.33^{d}
	Gautam	3.81^{bc}
	Aditya	4.2^{b}
	Borlaug 2020	4.29^{a}
LSD		0.24
CV (%)		4.07
Mean		3.38

NS represents non-significant difference among each other at 5% level of significance. DAS=Days after sowing, LSD= Least Significant difference, CV= Coefficient of variation.

Interaction effects: Table 5 highlights a significant interaction effect between sowing methods and varieties on grain yield. Line sowing of Borlaug 2020 produced the statistically maximum grain yield of 4.29 tons/ha, whereas broadcasting of Gautam produced the minimum grain yield. Statistically, the maximum grain yields were obtained by the combination of line sowing with different varieties.

Biological yield: The average biological yield was 6.23 tons/ha. Line sowing produced a higher yield of 6.41 tons/ha than broadcasting (6.05 tons/ha), which is statistically non-significant. Regarding varieties, Borlaug 2020 produced the maximum biological yield (6.60 tons/ha), followed by Aditya (6.38 tons/ha), Bijaya (6.17 tons/ha), and Gautam (5.79 tons/ha). However, non-significant effects were observed among different varieties. Table 4 shows non-significant effect of sowing methods and varieties on biological yield.

Conclusion

The comprehensive analysis of diverse sowing methods and wheat varieties at Gadhawa Dang provided valuable insights into growth and yield dynamics. Using a two-factorial Randomized Complete Block Design with line sowing and broadcasting, alongside Bijaya, Gautam, Aditya, and Borlaug 2020 varieties, provided nuanced understandings of wheat development. Line sowing, despite initial similarities, displayed superior traits such as increased plant height, higher tiller numbers, and higher yields in later stages. Varied responses among the varieties underscored the importance of selecting appropriate cultivars for specific traits. Borlaug 2020 showcased superior performance in terms of grains per spike and overall grain yield, while Bijaya excelled in thousand grain weight. The interaction effect highlighted the significance of pairing specific variety (Borlaug 2020) with optimal sowing method (Line sowing). This research enriches wheat cultivation strategies, emphasizing the necessity for tailored approaches considering both sowing methods and variety selection to optimize crop productivity.

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Authors contribution

Conceptualization, methology: A.A. and B.D.C.; Software, validation: A.A. and S.R.; Investigation: A.A. and B.D.C.; Data curation: A.A.; Writing -original draft preparation: A.A. and B.D.C.; Writing-review and editing: S.L.; Supervision: S.R., K.T. and S.L. All authors have read and agreed to the published version of the manuscript

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REFERENCES

Ashrafi, Z., Rahnavard, Y. A., & Sedigheh, S. (2009). Analogy potential effects of planting methods and tank mixed herbicides on wheat yield and weed populations. *Journal of Agricultural Technology*, 5(2), 391- 403.

Alomia-Hinojosaa, V., Speelmana, E. N., Thapa, A., Wei, H. E., McDonald, A. J., Tittonell, P., & Groot, J. (2018). Exploring farmer perceptions of agricultural innovations for maize-legume intensification in the mid-hill's region of Nepal. *International Journal of Agriculture Sustainability*, 16(1), 74-93.

Bhatta, R. D., Amagain, L. P., Subedi, R., & Kandel B.bP. (2020). Assessment of productivity and profitability of wheat using Nutrient Expert®-Wheat model in Jhapa district of Nepal. *Heliyon*, 6(6), e04144, https://doi.org/10.1016/j.heliyon.2020.e04144

Bhattarai, R. P., Thapa, D. B., Ojha, B. R., Kharel, R., & Sapkota, M. (2017). Cluster analysis of Elite spring wheat (*Triticum aestivum L.*) genotypes based on yield and yield attributing traits under irrigated condition. *International Journal of Experimental Research and Review (IJERR), 10*, 9-14.

Garapaty, R., Majumder, R., Thapa, D., Upadhyay, S.R., Baidya, S., Basnet, R., Bhandari, D., Gade, P., Paranjape, V., Killian, A., Vijayaraghavan, V. K., & Acevedo, M. (2021). DNA fingerprinting at farm level to map wheat variety adoption across Nepal. *Crop Science*, *61*(5), 3275-3287, https://doi.org/10.1002/csc2.20497

Hossain, M. B., Alam, M. S., & Ripon, M. A. (2013). Effect of irrigation and sowing method on yield and yield attributes of mustard. *Rajshahi University Journal of Life & Earth and Agricultural Sciences*, 41, 65-70.

Hussain, I., & Khan, M. A. (2003). Effect of row spacing on the grain yield and the yield component of wheat (*Triticum aestivum* L.). *Journal of Agronomy*, 2, 153-159.

Iqbal, M. J., Shams, N., & Fatima, K. (2022). Nutritional quality of wheat in: Ansari MR, editor. *Wheat*. London: *Intech Open*. https://doi.org/10.5772/intechopen.104659

Jaquet, S., Kohler, T., & Schwilch, G. (2019). Labor Migration in the Middle Hills of Nepal: Consequences on Land Management Strategies. *Sustainability*, *11*(5), 2-18.

Kandel, M., Bastola, A., Sapkota, P., Chaudhary, O., Dhakal, P., & Shrestha, J. (2018). Analysis of genetic diversity among the different wheat (*Triticum aestivum L.*) Genotypes. *Turkish Journal of Agricultural and Natural Sciences*, 5(2), 180-185.

Khatri, N., Pandey, B. P., Bista, M., & Ghimire, D.L. (2019). Effect of Different Wheat Variety and Sowing Methods on Grain Yield of Wheat under Bhairahawa Condition of Nepal. *International Journal of Life Sciences and Biotechnology*, *2*(3), 175-182.

Magar, P.B., Baidya, S., Thapa, D.B., Subedi, M., Basnet, R., & Pant, K.R. (2021). Evaluation of bread wheat genotypes for stripe rust resistance. *The Journal of Agriculture and Environment*, *22*, 146-155.

MOALD. (2019). Statistical Information on Nepalese Agriculture 2019/20, Ministry of Agriculture and Livestock development, Government of Nepal. Kathmandu.

MOALD. (2021). Statistical Information on Nepalese Agriculture 2020/21, Ministry of Agriculture and Livestock development, Government of Nepal. Kathmandu.

MOALD. (2022). Statistical Information on Nepalese Agriculture 2021/22, Ministry of Agriculture and Livestock development, Government of Nepal. Kathmandu.

MOALD. (2023). Statistical Information on Nepalese Agriculture 2022/23, Ministry of Agriculture and Livestock development, Government of Nepal. Kathmandu.

Pandey, D., Gautam, N. R., Pant, K. R., Upadhya, S. R., Thapa, D. B., & Puri, R. R. (2020). Wheat Varietal Development for Increasing Productivity in Hills of Nepal. *The Journal of Agriculture and Environment*, *21*, 142-150.

Reda, A. (2014). Evaluation of seed rates and sowing methods on growth, yield, and yield attributes of tef (*Eragrostis tef* (zucc)) in ada district, east sheva. Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *4*(23), 171-172.

Shah, A. M., Ali, S., Ahmad, I., Wazir, G., Shafique, O., Hanif, M. A., Khan, B. A., & Zareen, S. (2018). Weeds population studies and wheat productivity as influenced by different sowing techniques and herbicides. *Pakistan Journal of Agricultural Research*, *32*(1), 87-94, http://dx.doi.org/10.17582/journal.pjar/2019/32.1.87.94

Shtewy, N., & Al-Sharifi. S.K. (2020). Effect of Sowing methods, sowing depth and Sowing distances on technical characteristics and wheat yield. *Asia Life Sciences*, *10*(5), 775-781.

Singh, M., & Chaturvedi, P. K. (2023). Sowing methods and nitrogen levels effect on growth, yield and economics of wheat (*Triticum aestivum L.*). *The Pharma Innovation Journal*, *12*(1), 1030-1032.

Subedi, S., Ghimire, Y. N., Adhikari, S. P., Devkota, D., Shrestha, J., Poudel, H. K., & Sapkota, B. K. (2019). Adoption of certain improved varieties of wheat (*Triticum aestivum L.*) in seven different provinces of Nepal. *Archives of Agriculture and Environmental Science*, *4*(4), 404-409, https://dx.doi.org/10.26832/24566632.2019.040406

Timilsina, R. H., Ojha, G.P., Nepali, P.B., & Tiwari., U. (2019). Agriculture Land Use in Nepal. *Journal of Agriculture and Forestry University*, 3, 1-9.

Ullah, A., Khaliq, A., Riaz, A., Noor, M. A., Fiaz, S., Waqas, M. A., & Zain, M. (2018). Seed Pre-Treatment and Planting Geometry Positively Influence Herbicide Efficacy in Wheat (*Triticum aestivum*). *Scientific Electronic Library Online*. https://doi.org/10.1590/S0100-83582018360100008

Xu, J., Shen, Y., Zheng, Y., Smith, G., Sun, X. S., Wang, D., Zhao, Y., Zhang, W., & Li, Y. (2021). Duckweed (Lemnaceae) for potentially nutritious human food: A review. *Food Reviews International*, 1–15. https://doi.org/10.1080/87559129.2021.2012800