Agroeconomic Evaluation of Late Sown Wheat (Pak-13) for Nutrient Ratios and Seeding Densities under Rainfed Conditions

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Abstract: Breeding in wheat crop for improvement in new varieties having high yield, besides desirable and durable disease resistance is a continuous and long-term process and if it is coupled with better agro economic traits evaluation, there can be a clearer picture about the performance of newly developed cultivar in any crop species. A field study was conducted at the Research Farm Area of National Agricultural Research Centre, Islamabad, in wheat program during 2014-15, under late sown conditions. It was a 'Randomized Complete Block Design' with split plot arrangement, having fertilizer ratios in main plots and seeding densities in subplots. Both fertilizer ratios and seeding densities had four levels. From the analyzed data, it was revealed that under late sown circumstances, different nutrient ratios were statistically different in chlorophyll contents, number of tillers (m^{-2}) and biological yield ($kg\ ha^{-1}$), whereas, it was at par for plant height, spike length, leaf area and grain yield ($kg\ ha^{-1}$). It was also revealed that there were 22 and 21% higher tillers m^{-2} and biological yield ($kg\ ha^{-1}$), as compared to those conditions when there was no fertilizer application in the soil. In case of various seeding densities, a significant response was found for number of tillers (m^{-2}), biological yield ($kg\ ha^{-1}$) and grain yield ($kg\ ha^{-1}$). In case of interaction of nutrient ratios with seeding densities, a significant response was found only in biological yield ($kg\ ha^{-1}$) at F3 (90:60 N P $kg\ ha^{-1}$) $\times$ SD4 (140 $kg\ ha^{-1}$). While considering the benefit cost ratio (BCR) for nutrient ratios, it was found maximum at 45:30 level (F2) which was 1:8.45. In case of seeding densities, maximum BCR was observed in 80 $kg\ ha^{-1}$ (1:17.61).

Key words: Wheat, late sowing, nutrient ratios, seeding densities, benefit cost ratio

INTRODUCTION

Incidence of disease attack, breeding for high yielding wheat cultivars, coupled with modern biotechnological techniques, is going side by side since a time ago. Wheat is the Pakistan's major food crop, which is feeding the whole nation. Wheat contribution to the value added in agriculture and gross domestic production was 10 and 2.1%, respectively. The production of wheat stood at 25.478 million tonnes during 2014-15 (GoP., 2014-15). Wheat yield is low in Pakistan, as compared to other countries, due to many biotic and abiotic reasons, including the time of sowing and planting density, which are of great importance, deciding the appropriate stand establishment of the growing crop through harmonizing the plant to plant contest and ultimately affect the yield (Kabesh *et al.*, 2009; Nakano and Morita, 2009).

Among the several factors, responsible for low yield in Pakistan, the use of unbalanced rate of fertilizers and wrong seed rates are important and exploration on these

limiting factors on newly released cultivars will surely lead to high returns. Optimum seed rate is important for maximum yield and return for the crop. If higher seed rate is used, the plant population will be higher and there will be competition among plants for water, nutrients and sunlight which, in turn, may lead to low quality and low yield. If fewer seed rate is used, the yield will be less, due to lesser number of plants per unit area (Hameed *et al.*, 2003). Khan *et al.* (2002) reported that maximum grain yield was achieved with high seed rate, while minimum grain yield was obtained by low seed rate. "Optimum seeding density is an important management tool for improving yield of wheat. It is of scrupulous importance in wheat production because it is under a farmer's control in most cropping systems (Slafer and Satorre, 1999)." Optimum plant densities vary significantly between areas, climatic conditions, soil, sowing time and varieties. Seeding density is one of the prime determinants, which shows the ability of the crop to detain resources. There has been considerable focus on defining the relationship

between density and crop yield quantitatively in order to establish optimum populations and maximum reasonable yield under various situations. As a result, the effect of density on wheat plant size and crop productivity has received significant importance (Harper, 1977).

The judicious use of fertilizers can contribute to yield increments. Nitrogen (N) and Phosphorous (P) are the main important plant food nutrients and most of the soils are lacking in these nutrients (Ahmad *et al.*, 1999). The balanced use of N and P fertilizers is of significant importance in wheat production and their use in optimum share at appropriate time has a vital role on wheat yield. Plant species, even varieties within species, differ in their manners to acquire and utilize N and P for grain production (Ahmad *et al.*, 1992; Gill *et al.*, 1994). Mazurek and Kus (1991) reported that under late sown conditions having higher N rates reduced 1,000 grain weight, increased lodging and disease incidences besides improving protein yield and grain protein. Increase in cropping intensity and introduction of high yielding varieties have caused considerable decrease of N and crop storage positive response to added N in the soil (Ali *et al.*, 2004). "Nitrogen plays an imperative role in growth processes as it is an integral part of chlorophyll, protein and nucleic acid (Marschner, 1995; Jabbar *et al.*, 2009)." It is viewed as the central element because of its role in substance synthesis (Akhtar *et al.*, 1999). It constitutes 1.5-5 percent of the dry weight of higher plants (Novoa and Loomis, 1981). "Phosphorous scarcity is common in most of the soils of Pakistan and application of phosphatic fertilizer is considered crucial for crop production and motivates flourishing and seed formation (Memon, 1996)." Timely sowing of wheat crop in rainfed conditions is of prime importance as it contributes in gaining optimum grain yield as delay in planting, due to unavoidable weather conditions or due to delay in harvesting of previous crop, causes 10-15 kg reduction in yield on daily basis. So plant breeders must focus for breeding such type of varieties, which can perform better in late sown conditions besides performing well in normal planting windows already set by the scientists.

Keeping in view the prime importance of increasing fertilizer rates and cost of seeds in late sown conditions, the study was aimed to investigate the optimum equilibrium level of nutrient levels, seeding densities and BCR as due to changing climatic conditions sowing patterns need to be revisited.

MATERIALS AND METHODS

Optimum use of N and P fertilizers is the need of time in order to save resources under diminishing soil, energy and environmental conditions. Similarly, a good

crop stand can lead to get high returns in terms of grain yield and benefit cost ratio (BCR). A field study was planned and executed at Research Farm Area of National Agricultural Research Centre, Islamabad (33°42'N, 73°10'E) allotted to Wheat Program, during 2014-15. It was Randomized Complete Block Design, having split plot arrangements of treatments. Following treatments were used to achieve the targets.

Nutrient ratio kg ha ⁻¹ (Main plots)	Seeding density kg ha ⁻¹ (Sub plots)
F1 = Control (N:P = 0)	SD1 = 80
F2 = 45:30	SD2 = 100
F3 = 90:60	SD3 = 120
F4 = 135:90	SD4 = 140

It was replicated three times and the main plot was 6×5 m² and the subplot was 1.5×5 m². A newly developed wheat cultivar 'Pakistan 2013' was assorted under different treatment regimes. It was sown late in the 3rd week of December to evaluate its performance in relation to nutrient ratios and seeding densities. Before sowing of the crop, soil properties were also measured with standard sampling techniques. During the course of study, various traits, like plant height (cm), spike length (cm), chlorophyll contents (with the help of chlorophyll meter), leaf area, number of tillers m⁻², biological yield (kg ha⁻¹) and grain yield (kg ha⁻¹) were taken. Following procedures were used for taking the data on individual parameter of the crop. Four middle rows were harvested, they were air dried and weighed to record biological yield, which was converted on per hectare basis. Four rows were harvested for grain yield and threshed. After threshing, the grains were cleaned, dried and weighed to record the grain yield and were finally analyzed in Statistix Statistical software at 5% alpha level as described by Steel *et al.* (1997).

RESULTS AND DISCUSSION

Agroclimatic conditions (2014-15): The climatic conditions for the reported season under study are summarized in Fig. 1. Seasonal rainfall was 663.93 mm. The maximum rainfall was noted in the month of March (306.53 mm). The air temperature was normal during the season. Maximum air temperature of October 2014, November, December, January 2015, February, March and April, 2015 were 28.0, 24.6, 20, 23, 19.4, 22 and 27.5°C, respectively. The maximum average temperature was recorded in the month of April (27.5°C). The minimum average temperature was observed in the month of December (2.77°C). Average relative humidity from October, 2014 to April, 2015 varied from 68-78% and maximum was noted in the month of February, 2015, i.e., 78%. Wind speed during the reported season varied

from 20.2-37.5 km day⁻¹ and maximum was in the month of January, i.e., 37.5. Evapotranspiration was maximum in the month of April, 2015 (115.5 mm), whereas the lowest was noted in the month of December, 2014 (38.6 mm).

Soil profile status: Soil sampling was done before sowing of the crop and the data is given in Table 1.

Nutrient ratios: It is evident from Table 2, that varying nutrient ratios had no significant effect on plant height. The highest was noted in F4 level having 88 cm, whereas the lowest was recorded in control (85.85 cm). These results are in contrast with the findings of Malghani *et al.* (2010), they reported that there was significant effect of various nutrient ratios on plant height of wheat. In

Fig. 1: Agroclimatic conditions during crop season (2014-15)

Table 1: Soil status of NARC, wheat-land area (2014)

Parameters	Value
Soil texture	Loam
pH	7.79
OM	0.5%
Phosphorus	6.4 mg kg ⁻¹
Potassium	100 mg kg ⁻¹
Nitrogen	0.025%
TOC	0.29%

Table 2: Table of means showing nutrients ratios

Nutrient ratio (kg ha ⁻¹)	Plant height (cm)	Spike length (cm)	Chlorophyll content	Leaf area (cm ²)	No. of tillers (m ⁻²)	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)
F1 = 0 0	85.858	11.042	51.092 ^B	31.565	235.25 ^B	5208.3 ^C	1548.3
F2 = 45 30	86.375	11.046	53.783 ^A	32.190	255.58 ^{AB}	5708.3 ^{BC}	1642.5
F3 = 90 60	87.117	11.255	54.125 ^A	33.988	269.75 ^{AB}	6250.0 ^{AB}	1840.8
F4 = 135 90	88.008	11.358	52.492 ^{AB}	34.554	303.50 ^A	6625.0 ^A	1712.5
LSD at 5% level	NS	NS	2.4891	NS	49.437	747.76	NS

Table 2, it was shown that varying nutrient ratios had no significant effect on the spike length. The highest length was noted in F4 level, having 11.35 cm, whereas, the lowest was recorded in control (11.042 cm). These results are contrary to the findings of Laghari *et al.* (2010), who concluded that various fertilizer rates had significant effect on spike length in wheat cultivars. Further, varying nutrient ratios had significant effect on chlorophyll contents. The highest was noted in F3 level, having 54.125, whereas the lowest was recorded in control (51.09). From Table 2, it was shown that varying nutrient ratios had no significant effect on leaf area. The highest was noted in F4 level, having 33.55 cm², whereas the lowest was recorded in control (31.56 cm²). From Table 2, it was shown that varying nutrient ratios had significant effect on number of tillers m⁻². The highest was noted in F4 level, having 304, whereas the lowest was recorded in control (235). These findings are in line with the results of Niamatullah *et al.* (2011) and Tahir *et al.* (2004); they reported that application of various levels of fertilizers significantly increased the number of tillers m⁻². This might be due to increased nitrogen ratios, therefore, promoted greater stimulation of vegetative growth. All fertilizer levels had significant effect on vegetative growth of the plant depending upon the accessibility of the required nutrients, which leads to relative increase in tillers m⁻².

Varying nutrient ratios had significant effect on biological yield (kg ha⁻¹). The highest was noted in F4 level, having 6625 kg ha⁻¹, whereas the lowest was recorded in control (5208). High level of nitrogen promoted vegetative growth. These findings are in line with the work of Niamatullah *et al.* (2011), Tahir *et al.* (2004) and Laghari *et al.* (2010), they reported that varying fertilizer regimes had significant impact on biological yield (kg ha⁻¹) in wheat. The increase in biological yield with the increase in N, P levels may be due to the effect of nitrogen on vegetative growth of wheat as well as increase in tillers' number with higher rates of nitrogen. In Table 2, it was shown that varying nutrient ratios had no significant effect. The highest was noted in F3 level, having 1841 kg ha⁻¹, whereas the lowest was recorded in control (1548). These findings are in contrast with the work of Niamatullah *et al.* (2011),

Table 3: Table of means having various seeding densities

Seeding density (kg ha ⁻¹)	Plant height (cm)	Spike length (cm)	Chlorophyll content	Leaf area (cm ²)	No. of tillers (m ⁻²)	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)
SD1 = 80	86.258	10.988	51.767	32.194	259.58 ^{AB}	5500.0 ^C	1489.2 ^C
SD2 = 100	86.292	11.421	53.867	33.835	243.67 ^B	5750.0 ^{BC}	1587.5 ^{BC}
SD3 = 120	87.125	11.196	52.975	33.033	275.25 ^{AB}	6104.2 ^{AB}	1816.7 ^{AB}
SD4 = 140	87.683	11.096	52.883	33.234	285.58 ^A	6437.5 ^A	1850.8 ^A
LSD at 5% level	NS	NS	NS	NS	35.613	576.08	254.03

Table 4: Interaction of nutrient ratios with seeding densities for biological yield (kg ha⁻¹)

Nutrient ratio	Seeding density				Mean
	SD1 80	SD2 100	SD3 120	SD4 140	
F1 = 0 0	5083.3 ^B	5416.7 ^{AB}	5000.0 ^B	5250.0 ^{AB}	5208.35
F2 = 45 30	5166.7 ^{AB}	5583.3 ^{AB}	6333.3 ^{AB}	5833.3 ^{AB}	5708.3
F3 = 90 60	5500.0 ^{AB}	5833.3 ^{AB}	6166.7 ^{AB}	7500.0 ^A	6250
F4 = 135 90	6250.0 ^{AB}	6166.7 ^{AB}	6916.7 ^{AB}	7166.7 ^{AB}	6625.025
Means	5500	5750	6104.175	6437.5	
LSD at 5% level	2390.6				

Tahir *et al.* (2004) and Laghari *et al.* (2010), they reported that varying fertilizer regimes had significant impact on grain yield (kg ha⁻¹) in wheat.

Seeding densities: Table 3 shows that varying seeding densities had no significant effect on plant height. The highest was noted in SD4 level, having 87.68 cm, whereas the lowest was recorded in SD1 (86.25 cm). In Table 3, it was shown that varying seeding densities had no significant effect on spike length. The highest was noted in SD2 level, having 11.42 cm, whereas the lowest was recorded in SD1 (10.98 cm). The varying seeding densities had no significant effect on chlorophyll contents. The highest was noted in SD2 level, having 53.86, whereas the lowest was recorded in SD1 (51.76). The varying seeding densities had no significant effect on leaf area. The highest was noted in SD2 level, having 33.83 cm², whereas the lowest was recorded in SD1 (32.19 cm²). From Table 3, it was shown that varying seeding densities had significant effect on number of tillers m⁻². The highest was noted in SD4 level, having 286, whereas the lowest was recorded in SD2 (244). These results are in agreement with the work of Shah *et al.* (2011), who reported that various seeding densities were significantly different for number of tillers m² in wheat crop.

In Table 3, it was shown that varying seeding densities had significant effect on biological yield (kg ha⁻¹). The highest was noted in SD4 level, having 6438 kg ha⁻¹, whereas the lowest was recorded in SD1 (5500). These results are in conformation with the work of Shah *et al.* (2011); they reported that various seeding densities were significantly different biological yield (kg ha⁻¹) in wheat crop. In Table 3, it was shown that varying seeding densities had significant effect on grain yield. The highest was noted in SD4 level, having

1851 kg ha⁻¹, whereas the lowest was recorded in SD1 (1489). These results agree with the work of Shah *et al.* (2011) and Hussain *et al.* (2010), they reported that various seeding densities were significantly different for number of grain yield (kg ha⁻¹) in wheat crop.

Interactive effect of nutrient ratios with seeding densities: From the data given in Table 4, it was found that there was a significant interactive impact of various nutrient ratios to seeding densities for biological yield (kg ha⁻¹). Maximum was recorded at F3×SD4 (7500) followed by F4×SD4 (7166.7), whereas the minimum was noted in F1×SD1 (5083.3). These findings agree with those of Shah *et al.* (2011), they reported that there was significant effect of interactive influence of nutrient ratios with seeding densities.

Economic analysis: Economic analysis of wheat is calculated, using the data both for fertilizer and seed densities and, hence, benefit cost ratio is calculated from the same field trials data. The net returns of the data are calculated by the formula:

$$NR = TR - TC \quad (1)$$

While, BCR was computed by the following formula:

$$B/C = TR/TC \quad (2)$$

Table 5 clearly explains the economic analysis of wheat, affected by the use of various fertilizer levels. In case of different ratio of fertilizer trials, maximum (8.45) BCR was recorded from the plots, in which 137 kg ha⁻¹ fertilizer was applied, whereas, minimum (2.28) BCR was noted with maximum use of 412.3 kg ha⁻¹. The data

Table 5: Benefit cost ratio (BCR) for nutrient levels in wheat under late sown conditions

Sr. No.	Fertilizer ratio N:P (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Urea (kg ha ⁻¹)	DAP (kg ha ⁻¹)	Total fertilizer (kg ha ⁻¹)	Value of produce (Rs.)	Cost of fertilizer (Rs.)	Net return (Rs. ha ⁻¹)	BCR
F1	0-0	1548.3	0	0	0	74318.4	-	74318.4	-
F2	45-30	1642.5	72	65	137	78840.0	8340	70500.0	8.45
F3	90-60	1840.8	145	130.3	275.3	88358.4	16745.2	71613.2	4.28
F4	135-90	1712.5	217	195.3	412.3	82200.0	25085.2	57114.8	2.28

Table 6: Benefit cost ratio (BCR) for seed densities in wheat under late sowing conditions

Seed density (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Value of produce (Rs.)	Cost of seed (Rs.)	Net return (Rs.)	BCR
SD1 = 80	1489.2	71481.6	3840	67641.6	17.615
SD2 = 100	1587.5	76200.0	4800	71400.0	14.875
SD3 = 120	1816.7	87201.6	5760	81441.6	14.13917
SD4 = 140	1850.8	88838.4	6720	82118.4	12.22

further revealed that the use of fertilizer in delayed sown conditions was non-significant due to late rains. Moreover, it was also observed that wheat sowing after soybean (*Glycine max* L.) does not need much fertilizer and, in this case, the impact of nutrient ratios may be at par due to residual nitrogen prevalence in rhizosphere as nitrogen enhanced vegetative growth. Hence legumes must be included in cropping systems of wheat rotation in order to save fertilizer costs. It is clear from the data, given in Table 6, that when plots were seeded with 140 kg ha⁻¹, they produced maximum (Rs. 82118.4) net returns, while plots in which seed rate was used at 80 kg ha⁻¹, a minimum (Rs. 67641.6) net return was noted. The data also revealed that BCR was higher when seed rate was applied at 80 kg ha⁻¹ and gave (17.61) BCR, when plots were seeded with 140 kg ha⁻¹, then (12.22) BCR is minimum.

CONCLUSION

Rain fed crop production is a high risk task in Pakistani conditions when coupled with changing climatic conditions, increasing prices of seeds and fertilizers. For wheat crop, which is our staple food crop, a study was executed to investigate optimum seeding densities and nutrient ratios in order to get high returns in late sown conditions. From the analyzed data, it was revealed that there were 22 and 21% higher tillers m⁻² and biological yield (kg ha⁻¹) as compared to those conditions when there was no fertilizer application in the soil. Moreover, there was 16% increment in grain yield but it was statistically at par. In case of various seeding densities, 140 kg ha⁻¹ proved the best option for tillers m⁻², biological yield and grain yield (kg ha⁻¹). When interactive effect was considered, it was shown that (90 60 NP kg ha⁻¹)×140 kg ha⁻¹ seeding density produced the maximum biological yield in late sown conditions (7500), which was 32% higher as compared to no nutrient ratio×80 kg ha⁻¹ seeding density. In case of fertilizer maximum BCR is (8.45) at 137 kg ha⁻¹ and

incase of seed densities maximum BCR is (17.61) at 80 kg ha⁻¹. It is clear from the above data that in delayed cropping, various nutrient ratios were at par for grain yield and ideal results can be achieved only when breeding behavior of newly developed cultivar must be tested in normal and late sowing conditions.

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