E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2025; SP-8(1): 35-44
Received: 16-10-2024
Accepted: 23-11-2024

Mehak Nagora
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Shweta
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Meena Sewhag
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Kamala Malik
Department of Microbiology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Satyajeet
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Anuradha
Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Pragati Yadav
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Mehak Nagora
Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Comparative analysis of wheat varieties and mulch effects on crop performance

Mehak Nagora, Shweta, Meena Sewhag, Kamala Malik, Satyajeet, Anuradha and Pragati Yadav

DOI: https://doi.org/10.33545/2618060X.2025.v8.i1Sa.2319

Abstract
The field experiment was undertaken during *Rabi* season of 2019-20 at Agronomy research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar. The lay out of experiment was random block design with six wheat varieties (V_1- WH 1142, V_2- WH 1105, V_3- HD 2967, V_4- WH 1184, V_5- HD 3086 and V_6- WH 1124) and three mulch treatments (M_1- No mulch, M_2- Rice straw mulch @ 6 t/ha and M_3- Plastic mulch) having three replications. Wheat variety WH 1142 took more number of days to attain physiological maturity. Quality parameters *viz.* sedimentation value, protein content (%) and protein yield (kg/ha) were maximum under (M_2) rice straw mulch followed by (M_3) plastic mulch and (M_1) no mulch. Among varieties, highest sedimentation value and protein content were recorded with HD 2967, which was statistically on par with WH 1142. While, highest protein yield reported by variety WH 1142. Sowing of wheat under (M_2) rice straw mulch resulted in significantly higher yield attributes resulting in 29.75, 8.16, 5.36 and 27.71 per cent higher grain yield, attraction index and harvest index, respectively than (M_1) no mulch. Among wheat varieties, there was significant variation in terms of yield attributes because of varietal characteristics. Highest grain yield (5466 kg/ha) and biological yield (15318 kg/ha) were obtained from WH 1142. The highest attraction index (68.09%) and harvest index (40.46%) was attained by WH 1105.

Keywords: Attraction index, physiological maturity, protein content and sedimentation value

Introduction
Due to ongoing climate change, the need for the application of adaptive strategies in agriculture is increasing, particularly in areas with insufficient rainfall, high temperatures and weather fluctuations. Among various agricultural crops, wheat is one among the three most important cereals of world playing a very important role in global food security. It is the most widely grown crop of the world and used as staple food by billions of people (Shiferaw *et al*., 2013) [55]. About a third of the world's population relies heavily on wheat as a basic source of food supply (Lesk *et al*. 2016) [34]. The interaction of climate change and the growing population size poses significant challenges to the supply of food security. There are various biotic and abiotic stresses which affect productivity of wheat in india. Production of wheat is hugely affected by various biotic and abiotic sources. Among the abiotic stresses, drought, salinity, heat, and cold stresses severely impact on wheat production and these stresses are increasing due to the global climate change. The most detrimental abiotic stress which affects grain yield and the final quality of crop is heat stress (Kumar *et al*. 2023) [32]. This condition mostly prevalent in water scarce areas.
The excessive use of agrochemicals for managing abiotic stress creates environmental issues. This has increased the importance of alternative and environment-friendly management strategies. One of the most effective agronomic practises for water-scarce areas is the use of crop residues as a soil cover (mulch) in conservation agriculture (CA). (Nagora *et al*., 2023) [46]. Mulches put on the surface have various benefits for crop development and improvement in grain quality.
Varieties responded differently to agroclimatic conditions. So, screening of many varieties is necessary to select those which perform better under diverse weather conditions and can ultimately mitigate the negative impacts of environmental conditions on overall productivity of

wheat.

Overall, it can be said that combined use of mulches and competitive varieties is one of the agronomic practices that has potential to sustainably increase the crop productivity. Additionally, mulches enhance the soil's physical, chemical and biological qualities (Kasirajan and Ngouajio, 2012) [29] and boost crop yields (Brar and Walia, 2010) [10].

The literature review suggests that few research have been undertaken on wheat crop varieties and mulch materials to determine their effect on crop growth characteristics.To keep pace with the estimated yield, it is necessary to determine the efficacy of appropriate cultivars and mulch treatments in mitigating the adverse effects of climate change in semi-arid regions of Haryana. Therefore, research have been undertaken on wheat crop varieties and mulch materials to determine their effect on crop growth characteristics.

Materials and Methods

The present study was done in Rabi, 2019-20 at the Agronomy Farm of CCS HAU in Hisar, Haryana, which is located at 29°10' N latitude and 75°46' E longitude and has an elevation of 215.2 m above mean sea level. Hisar is located in the tract of semi-arid and subtropical monsoonal climate. The main features of climate in Hisar are dryness, high temperature and scanty rainfall. Availability of favourable temperature and solar radiation proved conducive for growth and yield attributing characters and eventually to the higher yield. The experimental material was consists of six wheat varieties (V_1-WH 1142, V_2-WH 1105, V_3-HD 2967, V_4-WH 1184, V_5-HD 3086 and V_6-WH 1124) and three mulch treatments (M_1- No mulch, M_2- Rice straw mulch @ 6 t/ha and M_3- Plastic mulch) having Factorial Random Block Design (RBD).

Observations recorded

Phenology: Days to emergence, Days to panicle initiation, Days to anthesis, Days to milking and Days to physiological maturity were recorded by counting the days from sowing to the date when 50% plants complete emergence in each plot. Among yield attributes, Spike length (cm), Number of spikelets per spike, Number of grains per spike, 1000 grain weight (g) were studied. Five representative spikes were harvested randomly in each plot. The spike length (cm) was measured from the base to the top of the spike and average spike length was calculated. From the selected spikes, the spikelets were separated and the number of spikelets was counted and the number of spikelets per spike was worked out. From the spikes selected for measuring spike length, the grains were separated from spikelets and the total numbers of grains were counted and the grains were counted in each spike. A composite sample of grains was taken from the produce of each net plot and 1000 grains were counted manually and weighed in gram.

Yield Parameters: Grain yield were obtained after threshing with the help of mini plot thresher, the grains obtained from each net plot area were weighed and converted into kg/ha. Straw yield (kg/ha) was calculated by substracting grain yield from biological yield for each of net plot area and expressed in kg/ha. Biological yield (kg/ha) were obtained after Sun dried weight of all harvested plants in each net plot was recorded and then converted into kg/ha. Attraction index (AI) (%) was calculated by dividing the grain yield by straw yield and multiplied by 100. Harvest index is the ratio of grain yield to biological yield and is expressed in per cent.

Quality parameters

Sedimentation value (ml): Sedimentation value in wheat flour and blends was determined according to procedure given by Mishra *et al.* (1998) [43]. 6 g weighed grain sample was transferred into 100 ml stoppered graduated cylinder. Added 50 ml distilled water into it and cylinder was shaken three times for 15 seconds horizontally *i.e.* left-right and then kept for few minutes. After this, 50 ml lactic-acid-sodium dodecyl sulphate (SDS) solution was added and mixed again. Finally, this cylinder was kept for half an hour and after that volume of sediments left as sedimentation value was noted down.

Protein content (%): Per cent nitrogen content in grain was determined by Nessler‟s reagent method. Then, protein content in wheat grain was calculated by multiplying the percentage of nitrogen in grains with 6.25. Protein content thus obtained was multiplied by grain yield to work out protein yield in wheat.

Nutrient studies

Nutrient content in grain (%)

A. **Collection, Preparation and Analysis of plant sample**: The grain sample of wheat crop were taken from each plot at physiological maturity and then dried in a hot air oven at 70 °C ± 5 for 48 hours. The samples grounded, passed through 40 mm sieve and then used for determination of NPK content in wheat samples as per following methods of analysis were adopted:
B. **Digestion of plant material:** The grounded grain sample (0.2) was taken in 50 ml conical flask and 5 ml mixture of diacid (H_2SO_4: $HClO_4$ in 9:1) was added and digested on a hot plate following the method described by Jackson (1973) [24] for determination of N, P and K in grain. The total volume of aliquot was made to 50 ml. The nutrient contents in sample were estimated by following methods.

1. **Nitrogen:** Nitrogen content in sample was estimated by method described by Lindner (1944) [35].
2. **Phosphorus:** The di-acid digested plant samples were analyzed for phosphorus content by vanado-molybdo phosphoric acid yellow colour method (Jackson, 1973) [24].
3. **Potassium:** Potassium content of the extract of tri-acid digested material was determined using ELICO flame photometer.

Nutrient uptake in grain (kg/ha): N, P and K content in grain at harvest was determined. For analysis of N, P and K, oven dried plant material (grain at harvest) from each plot was grinded separately with grinder and analysis the Nitrogen (Nessler‟s reagent method, Lindner, 1944) [35], phosphorus (Vanadomolybdo-phosphoric acid yellow colour method, Jackson, 1973) [24] and potassium (Flame photometer method, Richards, 1954) [52] contents in sample as described earlier. The uptake of each nutrient was computed by Equation 1:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient conc. in grain (\%) x grain yield (kg/ha)}}{100}$$

Soil studies: The soil samples were collected from 0-15 cm depth from each plot after harvesting of the crop.

Soil Biological properties

Total microbial count (Fungi, bacteria and yeast): 10 g of soil was suspended to 90 ml water blank and shaken for 30 minutes. Serial dilutions were made and 0.1 ml of dilutions were plated on the media. The plates were incubated at 30°C. Number of colonies were counted after 3-5 days. Different dilutions and growth media were used to estimate the different microbes (Table a, b and c). Microbial count in soil is computed by Equation 2

$$\text{Microbial count (CFU/g of soil)} = \frac{\text{No. of colonies}}{\text{Dilution factor x Amount of samle taken (g)}}$$

Table a: Potato Dextrose Agar (PDA) Medium

Component	Quantity (g/l)
Glucose	20.0
Extract of potatoes	250.0
Distilled water	1000
Agar	20.0

Table b: Nutrient Agar (NA) Medium

Component	Amount (g/l)
Glucose	5.0
Peptone	5.0
Sodium chloride	5.0
Beef extract	3.0
Agar	20.0
Distilled water	1000
Final Ph	7.4±0.2

Table c: Yeast Extract Peptone Sucrose (YPS) Agar Medium

Component	Quantity (g/l)
Yeast Extract	5.0
Peptone	5.0
Sucrose	60.0
Distilled water	1000
Agar	20.0

Statistical analysis: Data collected during the study were statistically analyzed by using the technique of analysis of variance (ANOVA) as applicable to Split plot design (Gomez and Gomez, 1984) [19]. The significance of the treatment effects was determined using F-test at 5% probability. To judge the significant difference between means of two treatments, the critical difference (C.D.) was worked out using Equation 3.

CD = √2 X EMS/n x t-value at 5% (Equation 3)

Where, CD = Critical difference
EMS = Error mean sum of square
n = Number of observations
t = Value of t-distribution at 5% level of error degree of freedom

Results and Discussion:

Phenology: Crop phenology is the study of periodic events in biological life cycles. Crop phenology is dependent on the three sets of variable i.e. genetic makeup of plant, agronomic practices and environment to which it is exposed. The duration of plant determines the yield potential of plant. It is an established fact that crop phenology is largely dependent on genetic and environmental factors *viz.* temperature, relative humidity, sunshine hours, rainfall *etc.* (Venkataraman and Krishnan, 1992) [64]. In the present study, there was significant variation in the days taken to emergence in different wheat varieties (Table 1). HD 3086 took maximum (8.89) and WH 1142 took minimum (6.56) number of days for crop emergence. WH 1184 (84.22) took maximum number of days to initiate panicle, which was significantly higher as compared to other wheat varieties under study. Reduction in days taken to anthesis was in the order of 7.31, 5.99, 4.87, 4.57 and 4.37 per cent in varieties WH 1105, WH 1124, HD 3086, WH 1142 and HD 2967 which took 101.33, 102.78, 104.00, 104.33 and 104.55 days, respectively as compared to WH 1184 (109.33).

Table 1: Effect of different mulch materials on phenological stages of different wheat varieties

Treatments	Days taken to emergence	Days taken to panicle initiation	Days taken to anthesis	Days taken to milk stage	Days taken to physiological maturity
Varieties					
V_1- WH 1142	6.56	80.00	104.33	128.44	156.00
V_2- WH 1105	8.11	76.33	101.33	122.44	153.67
V_3- HD 2967	8.56	80.00	104.55	126.89	154.89
V_4- WH 1184	8.00	84.22	109.33	131.67	154.00
V_5- HD 3086	8.89	79.22	104.00	127.44	154.67
V_6- WH 1124	7.78	77.56	102.78	126.11	151.88
SE(m)	0.34	0.46	0.50	1.06	0.47
CD (p=0.05)	0.97	1.32	1.44	3.05	1.35
Mulches					
M_1- No mulch	6.72	78.39	103.39	126.28	155.56
M_2- Rice straw mulch @ 6 t/ha	9.89	80.94	105.72	128.56	153.11
M_3- Plastic mulch	7.33	79.33	104.06	126.67	153.89
SE (m)	0.24	0.32	0.35	0.75	0.33
CD (p=0.05)	0.68	0.93	1.02	NS	0.96

Varieties which possess the ability to stay green under extreme temperature need a longer period of anthesis (Wahid *et al.*, 2007) [66]. Wheat variety WH 1184 took maximum no. of days (131.67) to reach milk stage than all other five varieties. Wheat variety WH 1142 took maximum number of days (156) to reach physiological maturity (156) which was significantly higher as compared to other five varieties and took 1.11, 1.33, 2.00, 2.33 and 4.12 more number of days to attain physiological maturity than HD 2967 (154.89), HD 3086 (154.67), WH 1184 (154.00), WH 1105 (153.67) and WH 1124 (151.88), respectively. The reason behind this is due to the fact that WH 1142 having long duration characteristics. Moreover, the differential behaviour of varieties to days required to reach the various phenological phases could be ascribed solely to their genetic makeup (Shah *et al.*, 2006; Amrawat *et al.*, 2013; Kalpana *et al.*, 2014; Khavse *et al.*, 2015; Uddin *et al.*, 2015 and Singh *et al.*, 2017) [54, 3, 28, 30, 61, 57].

With respect to mulch materials, the days taken for various phenological stages markedly influenced. (Table 1). Wheat crop sown under (M_2) rice straw mulch took (9.89) more no. of days as compare to sown under (M_3) plastic mulch and (M_1) no mulch treatment, which took 7.33 and 6.72 days, respectively, for emergence. This might be due to the load of mulch on emerging seedlings as reported by Ram *et al.*, 2013 [49]. Similar pattern was also recorded in terms of days taken to panicle initiation, anthesis and milk stage. These findings have similarity with Van Donk *et al.*, 2011 [63] who claimed that this might be due to change in soil temperature rather than soil water differences. Similar conclusions were also reported by Humphreys *et al.*, 2016 [22]. However, days taken for physiological maturity followed a reverse trend. The minimum no. of days to reach physiological maturity markedly decreased by application of (M_2) rice straw (153.11) than (M_1) no mulch treatment (155.56). This is in contrast to literature of Humphreys *et al.*, 2016 [22]. This might be due to the reason that application of mulch material increases temperature as a result of this grain development period was reduced significantly that led to early maturity of crop.

Yield attributes: The present investigation discovered that various varieties and mulch treatments had a substantial effect on yield and yield parameters such as spike length, number of spikelets per spike, number of grains per spike and 1000 grain weight.

Varieties and mulch materials had significant influence on spike length as mentioned in Table 2. The highest spike length (11.77 cm) was observed in WH 1124 and the lowest spike length (8.64 cm) was observed in HD 2967. The possible reason may be the genetic variation among the variety. These findings have similarity with the studies of Mani *et al.*, 2016 [39] who documented that spike length differs from variety to variety as it is a genetical trait.

The highest number of spikelets per spike reported from WH 1142 (24.41), while lowest reported from HD 3086 (18.32). This may be due to presence of significant genetic variability among wheat varieties as also noticed by previous researchers (Mani *et al.*, 2016) [39].

The highest number of grains per spike (66.21) was observed in case of HD 2967 (Table 2). While, lowest (45.053) was recorded in WH 1184. Again, genetic makeup may be the reason for the significant superiority of number of grains per spike, grain filling rate, 1000 grain weight of wheat varieties as reported by Haider, 2004 [21]; Deshmukh *et al.*, 2015 [15] and Mani *et al.*, 2016 [39]

Table 2: Effect of different mulch materials on spike length (cm), no. of spikelets per spike, no. of grains per spike and 1000 grain weight (g) of different wheat varieties

Treatments	Spike length (cm)	No. of spikelets/spike	No. of grains/spike	1000 grain weight (g)
Varieties				
V_1- WH 1142	10.28	24.41	55.51	43.00
V_2- WH 1105	10.01	19.50	50.67	41.11
V_3- HD 2967	8.64	21.52	66.21	43.44
V_4- WH 1184	10.70	20.84	45.03	38.33
V_5- HD 3086	9.08	18.32	49.24	46.89
V_6- WH 1124	11.77	19.20	47.34	43.89
SE(m)	0.22	0.61	0.62	0.65
CD (p=0.05)	0.64	1.75	1.80	1.88
Mulches				
M_1- No mulch	9.61	18.95	51.29	40.83
M_2- Rice straw mulch @ 6t/ha	10.94	22.43	53.53	45.06
M_3- Plastic mulch	9.69	20.52	52.18	42.44
SE (m)	0.16	0.43	0.44	0.46
CD (p=0.05)	0.46	1.24	1.27	1.33

The highest value of 1000 grain weight was observed in HD 3086 (46.89 g) and lowest was observed in WH 1184 (38.33 g). HD 3086 recorded 8.56, 5.78, 3.89, 3.45 and 3.00 g higher 1000 grain weight as compared to WH 1184 (38.33 g), WH 1105 (41.11 g), WH 1142 (43.00 g), HD 2967 (43.44 g) and WH 1124 (43.89 g). A stable genotype has low G x E interaction and performs equally under different environmental conditions. In the present study, varieties perform differently with respect to 1000 grain weight. Hence, it can be stated that varieties under study have high G x E interaction as a result of which showed significant variation in this character (Suresh and Munjal, 2020) [60].

The maximum spike length, number of spikelets per spike, number of grains per spike and 1000 grain weight (10.94 cm, 22.43, 53.53 and 45.06 g, respectively) were recorded under (M_2) rice straw mulch followed by (M_3) plastic mulch (9.69 cm, 20.52, 52.18 and 42.44 g, respectively) and (M_0) no mulch treatment (9.61 cm, 18.95, 51.29 and 40.83 g, respectively). This might be possible due to application of organic mulch which significantly improve Water use efficiency and Nutrient use efficiency in wheat plants (Chakraborty *et al.*, 2010) [11]. Additionally, Soil moisture was 4.2 per cent higher in mulched crop as compared to non-mulch crop which indicates that rice straw mulching is helpful to conserve moisture in the field (Dhaliwal *et al.*, 2019) [16]. Similar literatures were also reported by Chaudhary and Iqbal, 2013 [12]; Mani *et al.*, 2016 [39] and it also partially supported by Rummana *et al.*, 2018 [53].

Yields: Grain yield and straw yield markedly influenced by varieties and mulches. Among wheat varieties, highest grain yield (Table 4.7) was observed in WH 1142 (5466 kg/ha) which was at par with HD 2967 (5233 kg/ha), while lowest grain yield was recorded in WH 1105 (3477 kg/ha). This might be because the grain production is determined by yield-contributing features such as the number of spikelets per spike as well as growth parametes such as LAI, dry matter buildup, and photosynthates partitioning. The findings are consistent with those of Mahajan and Nagarajan, 2015 [37]; Kumar *et al.*, 2010 [31]; Purshotam *et al.*, 2010 [48]; Ram *et al.*, 2012 [50]; Deshmukh *et al.*, 2015 [15]; Mani *et al.*, 2016 [39]; Verma, 2015 [65]; Shirinzadeh *et al.*, 2017 [56]; Singh *et al.*, 2017 [57]; Yadav *et al.*, 2017 [68]. Additionally, straw yield followed a similar pattern like grain yield, the maximum straw yield (Figure 1) was recorded in WH1142 (9852 kg/ha).

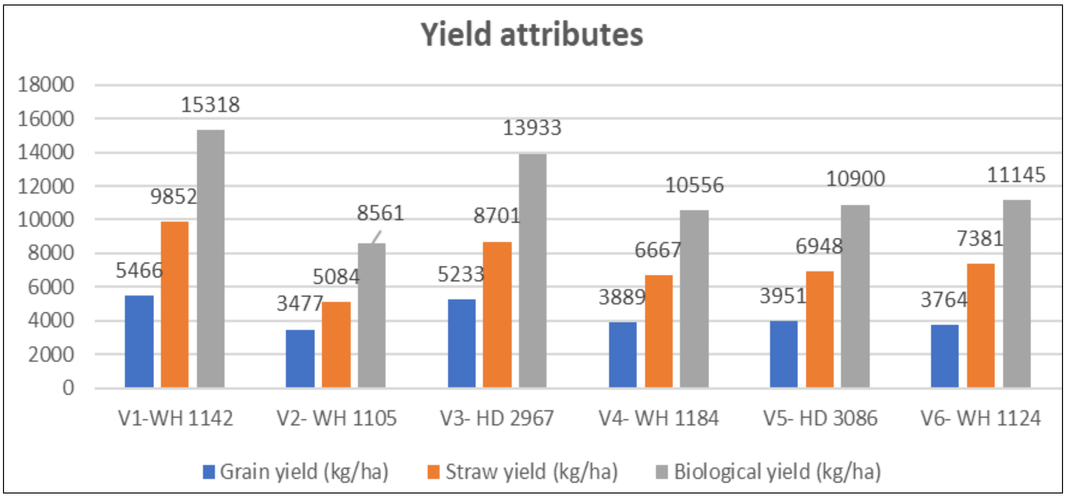

Fig 1: Effect of different varieties on grain yield, straw yield and biological yield (kg/ha) of different wheat varieties

Whereas, lowest straw yield was recorded in WH 1105 (5084 kg/ha). The results are corroborated by the relevant literatures of Deshmukh *et al.*, 2015 [15] and Kumari, 2015 [33], Nagora, *et al.*, 2022 [45] as these stated that rice straw mulch considerably increased growth metrics, yield characteristics and yield as well as N, P and K content and NPK absorption by straw.

Significantly, the highest grain and straw yield was reported under (M_2) rice straw mulch (5061 and 8341 kg/ha, respectively) followed by (M_3) plastic mulch (4274 and 7676 kg/ha, respectively), while lowest was observed under (M_O) no mulch treatment (3555 and 6300 kg/ha, respectively).

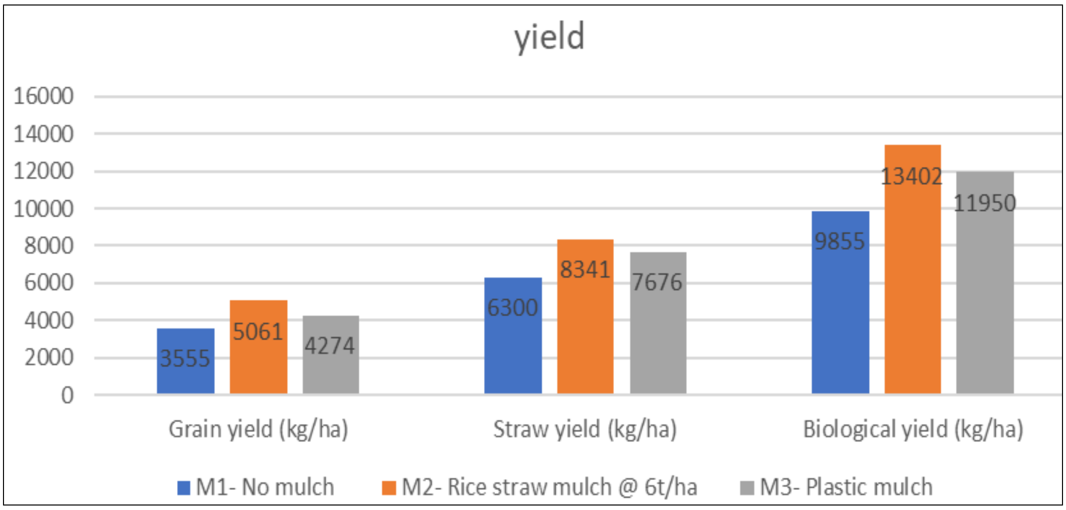

Fig 2: Effect of different mulch materials on grain yield, straw yield and biological yield (kg/ha) of different wheat varieties

Although, the plant population was less under rice straw due to load of mulch, but later it was curtailed by producing more no. of tillers as reported by Ram *et al.*, 2013 [49]. Hence, more grain and straw yield reported under rice straw mulch. Further, the grain and straw yield depends upon the plant height, dry matter accumulation, LAI and yield contributing parameters. The results are supported by the literatures of Humphreys *et al.*, 2016 [22]; Mani *et al.*, 2016 [39]; Akter *et al.*, 2018 [2]; Dhaliwal *et al.*, 2019 [16]; Javed *et al.*, 2019 [26] and partially supported by Rummana *et al.*, 2018 [53]. Subsequent absorption of stored soil moisture moderated the water status of plants, soil temperature and soil mechanical resistance, resulting in improved root development and grain yields. (Pervaiz *et al.*, 2009) [47].

Biological yield, Attraction index and Harvest index: The maximum biological yield was recorded in WH 1142 (15318 kg/ha), while minimum was recorded in WH 1105 (8561 kg/ha). The higher grain yield and and straw yield in WH 1142 resulted in higher biological yield of this variety. These findings are similar with the studies of Deshmukh *et al.*, 2015 [15]; Upadhay *et al.*, 2015; Verma, 2015 [65] and Mani *et al.*, 2016 [39].

Irrespective of all other yield attributes, the highest attraction index was reported by WH 1105 (68.09%), while lowest reported by WH 1124 (50.83%). This might be because of cumulative effect of grain and straw yield on attraction index.

Wheat variety WH 1105 recorded highest harvest index (40.46%), which was significantly higher as compared to other varieties. WH 1105 recorded 16.7, 11.8, 10.6, 9.27 and 7.39 per cent higher harvest index in comparison with WH1124, WH 1142, HD 3086, WH 1184 and HD 2967, respectively (Table 3). Harvest index (HI) has positive relation with grain yield and negative relation with biological yield. In contrast to grain yield and biological yield, the highest harvest index in WH 1105 was reported because of cumulative effect of grain and biological yield.

Table 3: Effect of application of different mulch materials on Attraction index (%) and Harvest index (%) of different wheat varieties

Treatments	Attraction index (%)	Harvest index (%)
Varieties		
V_1-WH 1142	55.55	35.68
V_2- WH 1105	68.09	40.46
V_3- HD 2967	59.97	37.47
V_4- WH 1184	58.13	36.71
V_5- HD 3086	56.85	36.14
V_6- WH 1124	50.83	33.68
SE(m)	1.25	0.50
CD (p=0.05)	3.60	1.45
Mulches		
M_1- No mulch	56.47	35.95
M_2- Rice straw mulch @ 6t/ha	61.49	37.99
M_3- Plastic mulch	56.76	36.13
SE (m)	0.88	0.36
CD (p=0.05)	2.55	1.02

Among different mulch materials, similar trend like other yield attributes was observed in case of biological yield (kg/ha), attraction index (%) and harvest index (%) as represented in Table 3. These are critical parameters that indicate the efficiency with which dry matter is partitioned to economic portion of the crop. Under different agronomic practices, the higher the harvest index, greater the economic return of crop. The other possible reason for this may be availability of sufficient moisture for proper vegetative growth and development of the crop increased the plant height, dry matter accumulation, number of tillers and leaf area index of crop, which contributed in increased photosynthesis activity and in turn higher yield attributes were produced. The results have been confirmed with the literatures of Mani *et al*., 2016 [39]; Humphreys *et al*., 2016 [22] and Rummana *et al*., 2018 [53].

The variation in yield attributes and yield may be because of the variation in genetic potential of varieties and environmental factors. The annual variation in productivity of wheat resulted because of climate change. As a result of climate change, the incidence of extreme weather events has increased. Extremely high temperature during grain filling stage are the primary factor causing crop yield losses (Fageria, 2001) [18]. Ram *et al.*, 2012 [50] reported similar genotypic variation in yields and harvest index. Several researchers have also noticed the variation in the varieties of wheat for yields attributes (Mahajan and Nagarajan, 2005 [37]; Kumar *et al*., 2010 [31]; Purshotam *et al*., 2010 [48]; Upadhyay *et al*., 2015 [62]; Kumari, 2015 [33]; Verma 2015 [65]; Mani *et al*., 2016 [39]; Shirinzadeh *et al.*, 2017 [56]; Singh *et al.*, 2017 [57] and Yadav *et al*., 2017 [68]).

Quality parameters: Sedimentation value (ml) and protein content (%) are two important quality parameters in wheat crop. Sedimentation value affected significantly by application of different varieties. Highest sedimentation value (55.98 ml) was recorded in HD 2967 (Table 4), which was significantly superior than other five varieties under study. HD 2967 resulted in 39.51, 29.02, 20.32, 16.04 and 5.62 per cent higher sedimentation value as compared to WH 1142, WH 1184, HD 3086, WH 1124 and WH 1105, respectively, represented in Table 4.8. This highly significant differences for quality parameters among different wheat varieties can be attributed to their genetic characteristics. This kind of variation in terms of sedimentation value among varieties also reported by Dangi and Khatkar, 2017 [14].

Sedimentation value also affected significantly by application of different mulch material (Table 4). It has been found that mulches have positive impact on sedimentation value. The highest sedimentation value (45.79 ml) was obtained under (M_2) rice straw and lowest reported under (M_1) no mulch treatment (45.49 ml). The reason might be due to positive correlation between protein content (%) and sedimentation value (ml) (Wurschum *et al*., 2016) [67].

In case of protein content, wheat varieties also gave significant variation as mentioned in Table 4.8. Similar like sedimentation value, wheat variety HD 2967 registered maximum (11.42%) protein content, while minimum was recorded in WH 1105 (10.19%). Similar findings are confirmed with the studies of Dangi and Khatkar, 2017 [14] who claimed that protein content can be assessed by sedimentation value, which is considered as an index of quality parameter. Further, protein amount in grain depends on the nitrogen concentration in grain as documented by Mehta *et al*., 2006 [41] and Mondal *et al*., 2015 [44] and in this study, the nitrogen concentration followed the similar pattern.

Wheat variety WH 1142 recorded highest protein yield (611.84 kg/ha), which was on par with HD 2967 (597.89kg/ha), but significantly higher than other varieties under study, while lowest protein yield (354.81 kg/ha) was reported by WH 1105. The cumulative effect of protein content and grain yield might have resulted in highest and lowest protein yield in WH 1142 and WH 1105, respectively. It has been observed that there was no significant influence of application of mulches on protein content in wheat grain. Although, numerically, maximum protein content (10.92%) reported under (M_2) rice straw mulch followed by (M_3) plastic mulch (10.80%) and (M_1) no mulch treatment (10.68%). This might be due to more uptake of nitrogen as mulch application provide better moisture availability (Maurya *et al*., 2017) [40] and more mass flow because of improving nutrient preservation than no mulch treatment as reported from the findings of Aulakh *et al*., 2000 [5]. This findings also have conformity with Balla *et al*., 2009 [7], who reported the relative rise in protein content under high temperature condition during grain filling period as application of mulch as soil cover increases the temperature by 2-5° C (Stirling *et al*., 2004) [59]. Further, the impact of mulch on protein yield affected significantly in contrast to protein content but, numerically, it follows the similar pattern as that of protein content. The possible reason for this can be positive impact of mulch application on grain yield (kg/ha) as well as on protein content (%) (Table 4). These studies are having partial similarity with the findings of Luo *et al*., 2018 [36].

Table 4: Effect of different mulch materials on Sedimentation value (ml), Protein content (%) and Protein yield (kg/ha) of different wheat varieties

Treatments	Sedimentation value (ml)	Protein content (%)	Protein yield (kg/ha)
Varieties			
V_1-WH 1142	52.83	11.19	611.84
V_2- WH 1105	33.87	10.19	354.81
V_3- HD 2967	55.98	11.42	597.89
V_4- WH 1184	39.79	10.48	408.36
V_5- HD 3086	47.00	10.83	428.52
V_6- WH 1124	44.60	10.69	402.22
SE(m)	0.07	0.15	9.90
CD (p=0.05)	0.20	0.44	28.56
Mulches			
M_1- No mulch	45.49	10.68	382.53
M_2- Rice straw mulch @ 6 t/ha	45.79	10.92	554.85
M_3- Plastic mulch	45.74	10.80	464.44
SE (m)	0.05	0.11	7.00
CD (p=0.05)	0.14	NS	20.20

Nutrient content in grain: Nutrient contents were estimated in grain of wheat crop at the time of harvest (Table 5). The varieties differed significantly with respect to nitrogen, phosphorus and potassium contents in grain. The highest (1.83%) and lowest content (1.63%) of nitrogen in grain recorded by HD 2967 and WH 1105, respectively. The probable reason for this is that varieties showed significant variation in nitrogen content in grain because of their unique genetical characteristics as reported by Belete *et al.*, 2018 [8]. The maximum phosphorus content (0.54%) in grain was recorded by HD 2967. Whereas, the lowest phosphorus content (0.45%) in grain was recorded by WH 1105. Highest potassium concentration (0.44%) in grain was recorded from HD 2967. Whereas, the lowest potassium content (0.33%) in grain was recorded from WH 1105. Varieties differed significantly in terms of nutrient content in grain as reported from the literatures of Arduini *et al.*, 2006 [4]; Bhakt *et al.*, 2010 [6]; Dangi and Khatkar, 2017 [14].

Table 5: Effect of different mulch materials on grain NPK content (%) of different wheat varieties

Treatments	N content	P content	K content
Varieties	**Grain**	**Grain**	**Grain**
V_1- WH 1142	1.79	0.51	0.42
V_2- WH 1105	1.63	0.45	0.33
V_3- HD 2967	1.83	0.54	0.44
V_4- WH 1184	1.68	0.47	0.34
V_5- HD 3086	1.73	0.50	0.39
V_6- WH 1124	1.71	0.52	0.36
SE(m)	0.02	0.003	0.01
CD (p=0.05)	0.07	0.008	0.01
Mulches			
M_1- No mulch	1.70	0.49	0.37
M_2- Rice straw mulch @ 6t/ha	1.75	0.51	0.40
M_3- Plastic mulch	1.73	0.50	0.38
SE (m)	0.02	0.002	0.01
CD (p=0.05)	NS	0.006	0.01

The effect due to different mulch treatment was non-significant on nitrogen concentration in grain. Although, highest nitrogen content in grain reported under (M_2) rice straw mulch (1.75) followed by (M_3) plastic straw mulch (1.73) and (M_1) no mulch treatment (1.70). The similar findings documented by Aulakh *et al.*, 2000 [5]; Maurya *et al.*, 2017 [40] and Ahmed *et al.*, 2020 [1] as they reported that application of mulch will improve the nitrogen concentration in grain because of availability of adequate moisture and more nutrient preservation than no mulch plots.

It has been observed that mulch influence the phosphorus and potassium contents in grain significantly. The maximum nutrient contents in grain were recorded under (M_2) rice straw mulch and the lowest nutrient concentration in grain and straw was achieved under (M_1) no mulch treatment. The possible reason is uptake of more nutrients by crop in the presence of sufficient moisture because of application of mulch, that helped to increase in the growth of the crop which subsequently leads to increase in yield of wheat. Similar findings have been discovered by Hussian *et al.*, 2017 and Ahmed *et al.*, 2020 [1] who documented that there is positive influence of mulch on nutrient content in grain.

Nutrient uptake by grain: The uptake of nutrients by grain and straw affected significantly due to varieties. Among the varieties, considerably higher grain N uptake (97.89 kg/ha) was observed under the variety WH 1142 over others five varieties. This result supported by the findings of Maltas *et al.*, 2018 [38] who reported the significant effect of cultivar on total N uptake as distribution of nutrients in plant parts is one of the most important determinations of yield and quality. Nitrogen uptake is positively correlated with grain yield, protein content and grain quality. Increase in efficiency of nitrogen is an important way for increasing grain N concentration.

Table 6: Effect of different mulch materials on grain and straw NPK uptake (kg/ha) of different wheat varieties

Treatments	N uptake by Grain	P uptake by Grain	K uptake by Grain
Varieties			
V_1- WH 1142	97.89	27.90	22.99
V_2- WH 1105	56.77	15.70	11.79
V_3- HD 2967	95.66	28.30	23.07
V_4- WH 1184	65.34	18.51	13.28
V_5- HD 3086	68.56	19.80	15.46
V_6- WH 1124	64.36	19.65	13.63
SE(m)	1.58	0.43	0.38
CD (p=0.05)	4.57	1.25	1.10
Mulches			
M_1- No mulch	61.20	17.49	13.39
M_2- Rice straw mulch @ 6 t/ha	88.78	25.96	20.31
M_3- Plastic mulch	74.31	21.49	16.40
SE (m)	1.12	0.31	0.27
CD (p=0.05)	3.23	0.88	0.78

The highest phosphorous uptake by grain (28.30 kg/ha) reported by HD 2967. Like P uptake, similar pattern was followed in terms of K uptake by plants. Nutrient distribution in various plant parts is influenced by genotypes, environment condition and their interaction (Fageria, 2001) [18]. The results have conformity with the literatures of Balla *et al.*, 2009 [7] and Dangi and Khatkar, 2017 [14] who revealed that varieties presented broad spectrum of variation in quality parameters especially nutrient uptake as represented in Table 6.

Different mulch treatments significantly influenced the uptake of nitrogen, phosphorus and potassium by wheat plants. Out of various mulch treatments, the highest total nitrogen, phosphorus and potassium uptake were recorded under (M_2) rice straw mulch (88.78, 25.96 and 20.31 kg/ha N, P and K respectively) followed by (M_3) plastic straw mulch. While, the lowest total nitrogen, phosphorus and potassium uptake were recorded under (M_1) no mulch treatment (61.20, 17.49 and 13.39 kg/ha, respectively).

As the uptake of nutrient was calculated by nutrient content in grain with their yields, hence, it was obvious to increase with the increment in grain and straw yield under mulch treatment than control. Apart from providing essential macro and micronutrients, organic mulch also contributes a suitable quantity of humic substances to the soil, maintaining the pH of soil that is favourable for plant growth and development resulting in improved nutrient uptake. The uptake of nutrients by plants from the soil system is dependent on a number of interrelated factors, the most significant of which are the absolute and relative concentrations of ions in the external medium as well as in the plant tissues, the roots' capacity for cation exchange and the relative mobility of hydration (Stewart, 1947) [58].

The increased absorption of N, P and K by grain and straw under mulch application is due to the increased availability of these nutrients which promotes crop growth and development resulting in increased grain and straw production. This is feasible due to increased mineralization of nutrients caused by the application of mulch which increases wheat's NUE (nutrient usage efficiency). The findings of Aulakh *et al*., 2000 [5]; Merwe and Prins, 2012 [42]; and Maurya *et al*., 2017 [40] are in accordance of these results.

Soil microbial studies at harvest: Variation within varieties also varied significantly. The maximum fungi population (9.15 x 10^5 CFU/g of soil) recorded from the soil taken from WH 1142 which was at par with HD 2967 (8.27 x 10^5 CFU/g of soil), while minimum reported from WH 1105 (4.23 x 10^5 CFU/g of soil). Among varieties maximum bacterial population (11.74 x 10^5 CFU/g of soil) recorded from WH 1142 which was at par with HD 2967 (11.19 x 10^5 CFU/g of soil), while minimum reported from WH 1105 (5.37 x 10^5 CFU/g of soil). Among varieties, maximum yeast population (12.47 x 10^5 CFU/g of soil) recorded from WH 1142 which was significantly higher than other varieties under study, while minimum reported from WH 1105 (5.07 x 10^5 CFU/g of soil). The reason behind this may be because of more organic carbon percentage which leads to presence of more microorganisms.
Microbial population also affected significantly by application of different mulch materials. It has been observed that highest fungal, bacterial and yeast population (8.29 x 10^5, 12.35 x 10^5 and 14.29 x 10^5 CFU/g of soil, respectively) was reported by (M_2) rice straw mulch followed by (M_3) plastic mulch and (M_1) no mulch treatment. Implementation of mulch can enhance the activity and number of soil microorganisms as demonstrated by Chen *et al*., 2014 [13] and Dong *et al*., 2017 [17]. Guo *et al.* (2015) [20] reported that utilization of mulch as soil cover can alter the physiochemical properties of soil by increasing microbial population.

Table 7: Effect of different mulch materials on soil microbial count (CFU/g of soil x10^5) of different wheat varieties after harvest

Treatments	PDA	NA	YPS
Varieties			
V_1- WH 1142	9.15	11.74	12.47
V_2- WH 1105	4.27	5.37	5.07
V_3- HD 2967	8.27	11.19	10.20
V_4- WH 1184	4.91	5.44	6.16
V_5- HD 3086	7.49	7.68	9.94
V_6- WH 1124	5.06	5.37	8.63
SE(m)	0.31	0.62	0.59
CD (p=0.05)	0.91	1.80	1.70
Mulches			
M_1- No mulch	4.83	2.79	4.03
M_2- Rice straw mulch @ 6 t/ha	8.29	12.35	14.29
M_3- Plastic mulch	6.46	9.08	7.92
SE (m)	0.22	0.44	0.41
CD (p=0.05)	0.64	1.27	1.20

Conclusion
Quality parameters, yield characteristics and yield were considerably greater under the variety WH 1142 than other five varieties studied. Rice straw mulch considerably increased growth metrics, yield characteristics and yield as well as N, P and K content and NPK absorption by grain. Sowing of wheat under (M_2) rice straw mulch resulted in significantly higher yield attributes resulting in 29.75, 8.16 and 5.36 per cent higher grain yield, attraction index and harvest index, respectively than (M_1) no mulch.

References

1. Ahmed S, Raza MAS, Saleem MF, Zaheer MS, Iqbal R, Haider I, *et al*. Significance of partial root zone drying and mulches for water saving and weed suppression in wheat. J Anim Plant Sci. 2020;30:154-162.
2. Akter S, Sarker UK, Hasan AK, Uddin MR, Hoque MMI, Mahapatra CK. Effects of mulching on growth and yield components of selected varieties of wheat (*Triticum aestivum* L.) under field condition. Arch Agric Environ Sci. 2018;3:25-35.
3. Amrawat T, Solanki NS, Sharma SK, Jajoria DK, Dotaniya ML. Phenology, growth, and yield of wheat in relation to agrometeorological indices under different sowing dates. Afr J Agric Res. 2013;8:6366-6374.
4. Arduini I, Masoni A, Ercoli L, Mariotti M. Grain yield, dry matter, and nitrogen accumulation and remobilization in durum wheat as affected by variety and seeding rate. Eur J Agron. 2006;25:309-318.
5. Aulakh MS, Khera TS, Doran JW. Yields and nitrogen dynamics in a rice-wheat system using green manure and inorganic fertilizer. Soil Sci Soc Am J. 2000;64:1867-1876.
6. Bakht J, Shafi M, Zubair M, Khan MA, Shah Z. Effect of foliar vs. soil application of nitrogen on yield and yield components of wheat varieties. Pak J Bot. 2010;42:2737-2745.
7. Balla K, Karsai I, Veisz O. Analysis of the quality of wheat varieties at extremely high temperatures. Cereal Res Commun. 2009;37:13-16.
8. Belete F, Dechassa N, Molla A, Tana T. Effect of nitrogen fertilizer rates on grain yield and nitrogen uptake and use efficiency of bread wheat (*Triticum aestivum* L.) varieties on the Vertisols of central highlands of Ethiopia. Agric Food Secur. 2018;7:1-12.
9. Bhardwaja V, Yadava V, Chauhan BS. Effect of nitrogen application timings and varieties on growth and yield of wheat grown on raised beds. Arch Agron Soil Sci. 2010;56:211-222.
10. Brar AS, Walia US. Rice residue position and load in conjunction with weed control treatments-Interference with growth and development of *Phalaris minor* Retz. and wheat (*Triticum aestivum* L.). Indian J Weed Sci. 2010;42:163-167.
11. Chakraborty D, Garg RN, Tomar RK, Singh R, Sharma SK, Singh RK, *et al*. Synthetic and organic mulching and nitrogen effect on winter wheat (*Triticum aestivum* L.) in a semi-arid environment. Agric Water Manag. 2010;97:738-748.
12. Chaudhary S, Iqbal J. Weed control and nutrient promotion in zero-tillage wheat through rice straw mulch. Pak J Weed Sci Res. 2013;19:465-474.
13. Chen Y, Wen X, Sun Y, Zhang J, Wu W, Liao Y. Mulching practices altered soil bacterial community structure and improved orchard productivity and apple quality after five growing seasons. Scientia Horticulturae. 2014;172:248-257.
14. Dangi P, Khatkar BS. Physicochemical and gluten quality characteristics of commercial wheat varieties. Int J Innov Res Sci Eng Technol. 2017;6:13448-13454.
15. Deshmukh KM, Nayak SK, Damdari R, Wanjari SS. Response of different wheat genotypes to different sowing time in relation to GDD accumulation. Adv Res J Crop Improv. 2015;6:66-72.
16. Dhaliwal LK, Buttar GS, Kingra PK, Singh S, Kaur S. Effect of mulching, row direction, and spacing on microclimate and wheat yield at Ludhiana. J Agrometeorol. 2019;21:42-45.
17. Dong W, Si P, Liu E, Yan C, Zhang Z, Zhang Y. Influence

of film mulching on soil microbial community in a rainfed region of north-eastern China. Sci Rep. 2017;7:1-13.
18. Fageria NK. Growth and mineral nutrition of field crops. 3rd ed. CRC Press; c2001.
19. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley and Sons Publication; c1984. p. 199-201.
20. Guo LJ, Zhang ZS, Wang DD, Li CF, Cao CG. Effects of short-term conservation management practices on soil organic carbon fractions and microbial community composition under a rice-wheat rotation system. Biol Fertil Soils. 2015;51:65-75.
21. Haider RS. Growth and yield response of three wheat varieties to N alone and in combination with P and P+K under late sown conditions. M.Sc. Thesis (Agronomy). University of Agriculture, Faisalabad, Pakistan; 2004.
22. Humphreys E, Kukal SS, Eberbach PL. Effects of tillage and mulch on the growth, yield and irrigation water productivity of a dry seeded rice-wheat cropping system in north-west India. Field Crops Res. 2016;196:219-236.
23. Hussain S, Khaliq A, Bajwa AA, Matloob A, Areeb A, Ashraf U, *et al*. Crop growth and yield losses in wheat due to little seed canary grass infestation differ with weed densities and changes in environment. Planta Daninha. 2019;35.
24. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi; c1973. p. 214-221.
25. Jat RS, Nepalia V, Chaudhary PD. Influence of herbicide and methods of sowing on weed dynamics in wheat (*Triticum aestivum*). Indian J Weed Sci. 2003;35:18-20.
26. Javed A, Iqbal M, Farooq M, Lal R, Shehzadi R. Plastic film and straw mulch effects on maize yield and water use efficiency under different irrigation levels in Punjab, Pakistan. Int J Agric Biol. 2019;21:767-774.
27. Joshi AK, Chand R, Arun B, Singh RP, Ortiz R. Breeding crops for reduced-tillage management in the intensive, rice-wheat systems of South Asia. Euphytica. 2007;153:135-151.
28. Kalpana A, Prusty P, Mukhopadhyay SK. Performance of wheat genotypes under different row spacing in New Alluvial Zone of West Bengal. J Crop Weed. 2014;10:480-483.
29. Kasirajan S, Ngouajio M. Polyethylene and biodegradable mulches for agricultural applications: a review. Agron Sustain Dev. 2012;32:501-529.
30. Khavse R, Deshmukh R, Verma N, Kausik D. Phenology, growth, and yield of wheat in relation to agrometeorological indices under different sowing dates. Plant Arch. 2015;15:81-87.
31. Kumar R, Mahajan G, Yadav MK, Keim DC. Effect of sowing dates and varieties on growth, yield and quality of wheat (*Triticum aestivum* L. emend Fiori & Paol.). Environ Ecol. 2010;28:1920-1924.
32. Kumar S, Kumar H, Gupta V, Kumar A, Singh CM, Kumar M, Kumar R. Capturing agro-morphological variability for tolerance to terminal heat and combined heat drought stress in landraces and elite cultivar collection of wheat. Front Plant Sci. 2023;14:1-16.
33. Kumari R. Performance of wheat genotypes on growth and yield under late sown condition. M.Sc. Thesis (Agronomy). Birsa Agricultural University, Kanke, Ranchi; 2015.
34. Lesk C, Rowhani P, Ramankutty N. Influence of extreme weather disasters on global crop production. Nature. 2016;529:84-87.
35. Lindner RC. Rapid analytical methods for some of the more common inorganic constituents of plant tissues. Plant Physiol. 1944;19:76.
36. Luo L, Wang Z, Huang M, Hui X, Wang S, Zhao Y, *et al*. Plastic film mulch increased winter wheat grain yield but reduced its protein content in dryland of northwest China. Field Crops Res. 2018;218:69-77.
37. Mahajan V, Nagarajan S. Heterosis for grain yield in wheat. Crop Res. 2005;29:466-468.
38. Maltas A, Dupuis B, Sinaj S. Yield and quality response of two potato cultivars to nitrogen fertilization. Potato Res. 2018;61:97-114.
39. Mani D, Singh MK, Prasad SK. Varieties and mulching influence on weed growth in wheat under Indo-Gangetic plain of India. J Appl Nat Sci. 2016;8:515-520.
40. Maurya AC, Verma SK, Kumar S, Lakra K. Nutrient concentration and their uptake and available nutrients in soil influenced by irrigation, mulching and integrated nutrient management in summer groundnut. Int J Curr Microbiol Appl Sci. 2017;6:2405-2415.
41. Mehta A, Kaur M, Gupta SK, Singh RP. Physico-chemical, rheological and baking characteristics of bread wheat as affected by farm yard manure and nitrogen management. J Res. 2006;43:263-270.
42. Merwe V, Prins JD. The effects of organic and inorganic mulches on the yield and fruit quality of ‘Cripps’ Pink’ apple trees. Ph.D. Thesis, Stellenbosch University, Stellenbosch; 2012.
43. Mishra BK, Gupta RK, Ram S. Protocols for evaluation of wheat quality. DWR, Karnal, India; c1998. p. 1-60.
44. Mondal H, Mazumder S, Roy SK, Mujahidi TA, Paul SK. Growth, yield and quality of wheat varieties as affected by different levels of nitrogen. Bangladesh Agron J. 2015;18:89-98.
45. Nagora M, Shweta, Sewhag M, Chaudhary K, Bhardhwaj N, Satpal, Bhardwaj S. Nutrient evaluation of wheat cultivars' straw grown under different mulching material for enhancing livestock performance. Forage Res. 2022;47:487-493.
46. Nagora M, Shweta, Sewhag M, Chaudhary K, Kumar L, Kumar S, Anjeeta. Potential role of wheat varieties in semi-arid areas of India with diverse mulch materials. Biol Forum Int J. 2023;15:293-300.
47. Pervaiz MA, Iqbal M, Shahzad K, Hassan AU. Effect of mulch on soil physical properties and N, P, K concentration in maize (*Zea mays* L.) shoots under two tillage systems. Int J Agric Biol. 2009;11:119-124.
48. Purshotam S, Parmeet S, Singh KN, Rekhi S, Aga FA, Bahar F, *et al*. Evaluation of wheat (*Triticum aestivum*) genotypes for productivity and economics under graded levels of nitrogen in temperate Kashmir. Indian J Agric Sci. 2010;80:380-384.
49. Ram H, Dadhwal V, Vashist KK, Kaur H. Grain yield and water use efficiency of wheat (*Triticum aestivum* L.) in relation to irrigation levels and rice straw mulching in North West India. Agric Water Manag. 2013;128:92-101.
50. Ram H, Singh G, Mavi GS, Sohu VS. Accumulated heat unit requirement and yield of irrigated wheat (*Triticum aestivum* L.) varieties under different crop growing environments in central Punjab. J Agrometeorol. 2012;14:147-153.
51. Rao AN, Chauhan BS. Weeds and weed management in India - a review. In: Weed Science in the Asian Pacific Region. Indian Society of Weed Science; c2015. p. 87-118.

52. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Handbook no. 60. United States Salinity Laboratory; c1954.
53. Rummana S, Amin AKMR, Islam MS, Faruk GM. Effect of irrigation and mulch materials on growth and yield of wheat. Bangladesh Agron J. 2018;21:71-76.
54. Shah WA, Bakht J, Ullah T, Khan AW, Zubair M, Khakwani AA. Effect of sowing dates on the yield and yield components of different wheat varieties. J Agron. 2006;5:106-110.
55. Shiferaw B, Smale M, Braun HJ, Duveiller E, Reynolds M, Muricho G. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food Sec. 2013;5:291-317.
56. Shirinzadeh A, Abad HHS, Nourmohammadi G, Haravan EM, Madani H. Effect of planting date on growth periods, yield and yield components of some bread wheat cultivars in Parsabad Moghan. Int J Farming Allied Sci. 2017;6:109-119.
57. Singh KM, Singh HK, Sohane RK, Singh A. Performance of wheat cultivars under irrigated late sown condition. J Exp Biol Agric Sci. 2017;5:472-475.
58. Stewart AB. Report on soil fertility investigation in India with special reference to manuring. Indian Council of Agricultural Research, New Delhi; 1947.
59. Stirling GR, Eden LM, Ashley MG. Sudden wilt of capsicum in tropical and subtropical Australia: a severe form of *Pythium* root rot exacerbated by high soil temperatures. Aust Plant Pathol. 2004;33:357-366.
60. Suresh SP, Munjal R. Selection of wheat genotypes under variable sowing conditions based on stability analysis. J Cereal Res. 2020;12:109-113.
61. Uddin R, Islam MS, Ullah MJ, Hore PK, Paul SK. Grain growth and yield of wheat as influenced by variety and sowing date. Bangladesh Agron J. 2015;18:97-104.
62. Upadhyay RG, Ranjan R, Negi PS. Influence of sowing dates and varieties on productivity of wheat under mid Himalayan region of Uttarakhand. Int J Trop Agric. 2015;33:1905-1909.
63. Van Donk SJ, Lindgren DT, Schaaf DM, Petersen JL, Tarkalson DD. Wood chip mulch thickness effects on soil water, soil temperature, weed growth, and landscape plant growth. J Appl Hortic. 2011;13:91-95.
64. Venkataraman S, Krishnan A. Crops and Weather. Publication and Information Division of ICAR, New Delhi, India; 1992.
65. Verma NS. Agronomic performance of new wheat varieties on different dates of sowing in Northern Madhya Pradesh. M.Sc. Thesis (Agronomy). College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.); 2015.
66. Wahid AS, Gelani MA, Foolad R. Heat tolerance in plants: An overview. Environ Exp Bot. 2007;61:199-223.
67. Wurschum T, Leiser WL, Kazman E, Longin CFH. Genetic control of protein content and sedimentation volume in European winter wheat cultivars. Theor Appl Genet. 2016;129:1685-1696.
68. Yadav V, Mishra DN, Chauhan RS, Tomar P, Singh R. Performance of newly released wheat (Triticum aestivum L.) varieties on different sowing dates under NWPZ of U.P. J Pharmacogn Phytochem. 2017;6:720-722