Good crop production practices

1: Climatic requirement

Wheat is grown in all types of climatic conditions i.e. tropical, sub-tropical and temperate. In India, major wheat is under cultivation in areas in the sub-tropical region. The cool and sunny winter is very conducive for growth of wheat crop. The range of temperature required for optimum growth and development of wheat is as under:

Growth stages	Temperature requirements
Germination	20 to 25°C mean daily
Vegetative growth	20 to 23°C mean daily
Grain filling	23 to 25°C mean daily

2: Soil requirement

Wheat can be grown on all kinds of soils, except the highly alkaline soils and water logged conditions. Soils with clay loam or loam texture, good structure and moderate water holding capacity are ideal for wheat cultivation. Durum wheat is preferably sown on medium to fine textured soils.

3: Agronomic Practices

- **Land Preparation**

The Wheat crop requires a well pulverized but compact seed bed for good uniform germination. One deep ploughing with soil turning plough followed by two harrowing and planking is desirable .

- **Seed and Sowing**

The optimum time of Sowing, Spacing & Seed Rate normally under specific production conditions are as follows

	Seed rate (kg/ha)	Time of sowing	Spacing (cm)
Irrigated Timely sown	100	10-25 November	20-23
Irrigated Late sown	125	25 Nov.-25 Dec.	15-18
Rainfed timely sown	100	25 Oct.-10 Nov.	20-25

The zone-wise broad optimum sowing time recommended are as follows:

Wheat Zones	Optimum sowing time
Northern Hills Zone (NHZ)	First Fortnight of November
Nort Western Plains Zone (NWPZ)	-do-
Nort Eastern Plains Zone (NEPZ)	Mid November
Central Zone (CZ)	-do-
Peninsular Zone (PZ)	First Fortnight of November
Southern Hills Zone (SHZ)	Last Week of November

- **Seed treatment & sowing**

To ensure good germination and establishment of diseased free crop stand seeds must be treated with fungicide like Thirum or Bavistin 50WP @ 2.5 g/kg seed. Where there is problem of loose smut treat the seeds with Carbendazim (Bavistin 50WP) @ 2.5 g/kg seed or Carboxin (Vitavax 75 WP) @ 1.5g/kg seed to facilitate speedy germination in case of late sowings. Seeds may be soaked overnight followed by drying in shed before sowing. The seeds should be placed 5-6 cm deep below the soil where sufficient soil moisture is available to enable germination. Use of biofertilisers like *Trichderma viridi* (@ 80 gms for every 10 gms of seeds) and *Azotobacter* & PSB (@ 200 gms per 10 gms of seeds) help for better plant stand at intial stage of the crop.

4: Wheat Varieties

ICAR and State Agriculture Universities has developed many varieties of Wheat suitable for different zones, regions, states and production conditions. The significant recent varieties that were released during the last 10 years include HD3043(2012), HD2967(2010), DBW71(2013),HD2987(2011) and DPW621-50(2011) recommended for the NWPZ. For the NEPZ, the recent varieties include Raj 4120(2008), K0307(2006), HD2985(2009), HPW349(2013) etc. The varieties viz., MP1202(2010), MP3336(2013), MP3288(2011) were among the recent ones in the central zone. UAS428 (2012) and NIAW1415(2011) were among the recently released varieties for the Peninsular Zone. For the Northern Hills Zone, HPW249(2010), HPW(349) were the prominent ones.

5: Fertilizer management- recommended doses for different ecologies, micro-nutrients, organic manures, application methods

Manures and fertilizers both play important roles in wheat cultivation. Use of Farm Yard manure improves the general physical condition and structure of the soil and its capacity to hold water. About 10 to 15 tons of FYM or compost should be applied 4 to 6 weeks before sowing and worked well into the soil. A crop of wheat yielding 50 quintals of grain per ha. removes 100 to 150 kg nitrogen, 70 to 80 kg phosphorus and 125 to 150 kg potash from the soil. The response of a given variety of wheat to application of fertilizer, however, varies from field to field and from locality to locality which should be regulated in accordance with the soil test value for the respective nutrients .

The recommended per hectare dose of nitrogen normally ranges from 120-150 kg under irrigated condition and half the dose under rainfed conditions in NWPZ and NEPZ. In other zones, the dosage of nitrogen ranges from 90-120 kg under irrigated and 60 kg per ha under rainfed conditions. The dosage of phosphorous and potash have been recommended to be 60 kg P2O5 and 40 kg per ha. The recommended dosage of various major nutrients for wheat are as under:

Table- : Fertilizers recommendations for wheat in different wheat growing agro-climatic zones

Zones	Sowing Conditions	Fertiliser dosage and Time of application
NWPZ & NEPZ	Irrigated timely sown	150:60:40 Kg NPK /ha 1/3 N and P+K at sowing time and 2/3 N at 1st node stage i.e. 35-40 DAS
	Irrigated late sown	120:60:40 Kg NPK /ha 1/3 N and P+K at sowing time and 2/3 N at 1st node stage i.e. 35-40 DAS
	Rainfed	60:30:20 Kg NPK /ha at time of sowing
NHZ,CZ, PZ &SHZ	Irrigated timely sown	120:60:40 Kg NPK /ha 1/3 N and P+K at sowing time and 2/3 N at 1st node stage i.e. 35-40 DAS
	Irrigated late sown	90:60:40 Kg NPK /ha 1/3 N and P+K at sowing time and 2/3 N at 1st node stage i.e. 35-40 DAS
	Rainfed	60:30:20 Kg NPK /ha at time of sowing

In light soils, deficiency of micronutrients(like Zinc, Mn,Sulfur) in wheat fields particularly in the Rice-Wheat system occurs . The general recommendation in the concerned micronutrient deficient soils is as follows:

Name of deficient micronutrient	Recommended Micronutrient combination to be applied	Application dosage	Application methods and frequency
Zinc	Zinc Sulphate	@ 25 kg/ha	At sowing once in a year in R-W system
	Foliar spray	0.5% zinc sulphate solution	2-3 sprays at 15 days interval in standing Zn deficient crop.
Manganese	Manganese sulphate	0.5% Manganese sulphate solution	2-3 sprays at weekly interval at 2-4 days before first irrigation
Sulphur	Gypsum	@250 kg/ha of Gypsum	At land preparation

6: Irrigation management:

The total water requirement of wheat crop is 450-650 mm, which need to be provided over first 100 days of crop growth uniformly. The loss of water through evaporation and transpiration from the wheat field i.e. evapotranspiration which directly influences the growth and yield of the crop. There is the need for 6 irrigations for wheat in general. However, in sandy loam soil 6-8 irrigations may be required whereas in heavy clay soil 3-4 irrigations are considered to be sufficient. The optimum time of irrigating wheat crop based on the physiological stages is one of the most important recommended methods of scheduling irrigation. Irrigations should be done at right time to minimize evaporation losses. The recommended time of irrigation is as below:

Status of Irrigation	Critical Crop Development Stage	Approximate date after sowing
1st Irrigation	At crown root initiation stage	20-25 days
2nd Irrigation	At tillering stage	40-45 days
3rd Irrigation	At node formation/late jointing or booting stage	60-65 days
4th Irrigation	At heading/flowering stage	80-85 days
5th Irrigation	At milk formation stage	100-105 days

6th Irrigation	At grain filling/dough stage	115-120 days

Irrigating the crop at the critical growth stages(each ranging from 6-8 cm depth) increases the yield of wheat significantly. Depending upon the availability of water, irrigation is recommended to be scheduled for specific critical physiological growth stages of the crop as follows:

Water availability for	**Crown Root Initiation stage (20-25 DAS)**	**Tillering stage (40-45 DAS)**	**Node formation/late jointing or booting stage (60-65DAS)**	**Heading/flowering stage (80-85DAS)**	**Milk stage (100-105 DAS)**	**Dough stage (115-120 DAS)**
1 irrigation	√					
2 irrigations	√			√		
3 irrigations	√		√		√	
4 irrigations	√	√	√		√	
5 irrigations	√	√	√	√	√	
6 irrigations	√	√	√	√	√	√

DAS= Days after sowing

Microirrigation :

Sprinkler and drip irrigation techniques are the micro irrigation technologies that lead to substantial savings of water in irrigating wheat. In areas of water scarcity or very limited water availability for irrigation, such micro-irrigation techniques are useful in improving the Water Use Efficiency(WUE) and the cost of production as a whole. The practice of sprinkler irrigation are in practice in Haryana in the NWPZ, Gujarat and Madhya Pradesh in Central Zone(CZ) and Maharashtra Peninsular Zone(PZ). Sprinkler and drip irrigation systems recorded significant yield for NWPZ (IW/CPE ratio of 1.20)with 5.3 t/ha, for CZ(IW/CPE ratio of 0.60) with 4.5 t/ha and for PZ ((IW/CPE ratio of 0.80) with 4.5 t/ha.(Ref. DWR,Karnal,2013-14). However, the initial high cost of the system and the higher recurring maintenance cost poses a hindrance particularly for the SMF.

7. Resource Conservation in Wheat Cultivation

7.1. Laser Land Leveller:

Recommendation is there for levelling of the land by Laser land leveler that makes the field ideal for uniform moisture distribution to be available for wheat crop's root zone. It increases the WUE by about 35-45% and Increased Nutrient Use efficiency by about 15-25% and with the yield advantage of more than 15%.

7.2. Surface Seeding Technology

In wheat growing areas where the soil remains moist for a long time after harvesting of Rice crop because of which the tillage operations becomes not possible to be taken up in time. In such areas as in eastern part of Indo-gangetic plains of India, dry or soaked wheat seeds can be sown a few days before or immediately after the harvest of the Rice crop under moist/ saturated soil conditions. This system of 'surface seeding' in wheat is most suitable for low land areas where the water received at a time advanced growth stage of wheat. The method , ideal for Rice – Wheat rotation, controls weeds, conserves resources and reduces cost of cultivation.

7.3.Zero- Tillage (ZT) Technology

Rice/DSR-Wheat system is one of the major and dominant cropping systems that occupied approximately 11 million hectares area in the Indo-Gangatic plains . To induce timely sowing of wheat within the range of optimum limit and to take advantage of available soil moisture for initial stand establishment, sowing wheat with the Zero Till ferti-cum-Seed Drill can be practiced. The practice is picking up in the Indo-gangetic plains but not recommended for heavy clay type soils. The technique can be adopted in Rice-Wheat system in particular as a constituent of Conservation Agriculture practices.

7.4.Furrow Irrigated Raised Bed-Planting (FIRB) System

The FIRB method helps in saving irrigation water upto 40% and increase NUE and other inputs for economic crop production. Various versions of the machine suitable for sowing of wheat and other crops on raised beds have been developed by different groups working on FIRB system. The method is also ideal for Rice – Wheat rotation for reduced cost of cultivation owing to reduced of basic inputs like seeds, fertilizer to the tune of 25%, increased WUE, management of obnoxious weeds like *Phalaris minor and* ultimately resource conservation.

7.5. Rotary Tillage Technology:

The Rotary Tillage Machine is a combination of rotary tiller, seed cum fertilizer drill and a light planker cum driving wheel and is advantageous over conventional tillage as the machine, completely pulverizes the soil, the seeding is done simultaneously, soil moisture is conserved and saves energy and time. The rotary-till-drill machine named as DWR Rotavator-cum-drill is suitable for sowing wheat both under normal and late sown conditions and economizes on fuel and the all important time especially when wheat sowing is delayed after Rice harvest, particularly of basmati type Rice. By this machine, sowing of wheat is completed in a single tractor operation leading to substantial savings on diesel consumption and time required for conventional field preparation.

8: Weed management:

8.1: Important Weed Flora:

The pre-dominant weeds are mostly annuals and associated with wheat crop are *Anagallis arvensis* (Krishananeel), *Argemone mexicana* (Satyanashi), *Asphodelus tenuifolius* (Piazi), *Avena ludoviciana* (Jangli Jai), *Cannabis sativa* (Bhang), *Carthamus oxycantha* (Pohli), *Chenopodium album* (Bathu), *Cirsium arvense* (Kateli), *Convolvulus arvensis* (Hirankhuri), *Cornopus didymus* (Pitpapra), *Euphorbia jelioscopia* (Dudhi), *Fumaria parviflora* (Gajri), *Lathyrus aphaca* (Matri), *Malva parviflora* (Gogisag), *Medicago denticulata* (Maina), *Malilotus alba* (Metha), *Phalaris minor*(Mandushi/Gulidanda), *Poa annua* (Poa ghas), *Polygonum plebejum* (Raniphul), *Polypogon monspeliensis* (Lomar ghas), *Rumex retroflex* (Jangli palak), *Spergula arvensis* (Bandhania), *Vicia sativa* (Chatri/Gegla).

Phalaris minor is the dominant weed of wheat in rice-wheat system found in NWPZ. Sometimes its population is so high (2000-3000 plants / m2) that farmers are forced to harvest the wheat crop as fodder. Isoproturon (Arelon) was recommended for the control of *Phalaris minor* in 1980s. It remained effective for almost a decade. But sole dependence on this herbicide resulted in the development of resistance to Isoproturon in controlling *Phalaris minor*. In zero tillage fields, the intensity of *Rumex* and *Malwa parviflora* is increasing and intending to become a problem in the coming years. Therefore, there is the requirement of strict vigilance regarding weed flora shift due to changes in tillage practices.

8.2: Weed Management Practices

Various practices of weed management can be grouped into three broad categories namely cultural and preventive; physical or mechanical; and chemical weed control. These practices are as under:

8.2.1: Cultural and Preventive

Cultural practices such as time and method of sowing, crop density and geometry, crop varieties, dose, method and time of fertilizer application, time and method of irrigation have pronounced effect on crop-weed interference. Some of these factors are use of clean wheat seeds that is free from weed seeds, early sowing of wheat (before 15 Nov.), adoption of closer row spacing (18 cm), adoption of cris-cross sowing to increase population density of the wheat plants, placement of basal dose of fertilizer 2-3 cm below the seed, sowing of wheat on FIRBS to reduce weed population, pulling out weeds before seed setting for curbing seed bank of weeds, keeping bunds & irrigation channels free from weeds, introduction of either Berseem or Oat for Fodder, as a crop rotation and sown once in three years, stimulate emergence of Phalaris by giving light irrigation followed by weed control with non-selective herbicides like glyphosate or cultivation followed by sowing of wheat, zero tillage offer a way to manage Phalaris and grow fast growing and robust varieties of wheat for smothering impact on weeds.

8.2.2: Mechanical Control

Removal of weeds by various tools & implements including hand weeding. It is not feasible where weeds resemble morphologically to crop e.g. *P. minor* & *Avena ludoviciana* before flowering. Also, mechanical weed control becomes difficult in broadcast sown wheat. However, mechanical control can be practiced effectively when wheat is sown on FIRBS as this system facilitates tractor mounted implements usage.

8.2.3: Chemical Control

Chemical weed control is in practice because of less labour involvement and no mechanical damage to the crop that happens during manual weeding hence cost effective. Moreover, the control is more effective as the weeds even within the rows are killed which invariably escape, because of morphological similarity to wheat, during mechanical control. The following Weedicides schedule has been found effective in controlling the Isoproturon resistant population of *Phalaris minor*. Out of the four new herbicides found effective against Phalaris, two namely Sulfosulfuran and Metribuzin were effective against both grassy and non-grassy weeds, whereas clodinafop and fenoxaprop were

specific to grassy weeds. The recommended herbicides for controlling different categories of weeds are as under:

Type of weeds to be managed	Herbicides recommended	Time of application	Dosage (g a.i./ha)
Grassy weeds	Clodinafop(Topik 15WP)	Post-em. at 30-35 DAS	60
	Fenoxaprop-ethyl (Puma Super 10EC)	Post-em. at 30-35 DAS	100-120
	Pinoxaden (Axial 5EC)	Post-em. at 30-35 DAS	35-40
	Sulfosulfuron (Leader 75 WG)	Post-em. at 30-35 DAS	25
	Isoproturon (Arelon 75WP)	Post-em. at 30-35 DAS	1000
	Pendimethalene (Stomp 30EC)	Pre-em. at 1-3 DAS	1000-1500
Broadleaved weeds	2,4-D-E (Weed war 38 EC)	Post-em. at 30-35 DAS	500
	Metsulfuron (Algrip 20WP)	Post-em. at 30-35 DAS	4
	Carfentrazone (Affinity 50WDG)	Post-em. at 30-35 DAS	20
	Pendimethalene (Stomp 30EC)	Pre-em. at 1-3 DAS	1000-1500
Both Grassy+Broadleaved Weeds together	Isoproturon (Arelon 75WP+ 2,4-D-E(Weedwar 38EC)	Post-em. at 30-35 DAS	750+500
	Sulfosulfuron 75% +Metsulfuron 5% (Total 80(75+5)WDG	Post-em. at 30-35 DAS	30+2
	Mesosulfuron + iodosulfuron (Atlantis 3.6 (3+0.6)WDG	Post-em. at 30-35 DAS	12+2.2

DAS=Days after sowing; a.i.=active ingredient

9: Plant protection:

Incidence of diseases and pests normally donot occur in wheat in severity except rusts. Rusts are the dreaded ones caused by fungal infestation. Among the three types of rusts in wheat, Stripe or Yellow rust and Stem or black rust, if allowed to continue uncontrolled for few days, can

cause 100% loss of wheat. The leaf or brown rust on the other hand, may cause 60% loss. Rusts along with other diseases occur in different locations of the country through survival in alternate hosts. The hotspot locations of different diseases are as follows:

Disease	Hot spot locations
Stripe rust	DhaulaKuan, Ludhiana, Gurdaspur, Karnal, Yamunanagar, Ambala, Nawashar, Ropar, Almora, Palampur and Wellington
Leaf rust	Ludhiana,Karnal,Hissar, Delhi, Pantnagar, Durgapura, wellington, Mahabaleshwar and Dharwad
Stem rust	Indore, Powerkheda, Junagad, Vijapur, wellington, Mahabaleshwar, pune and Niphad
Karnal bunt	DhaulaKuan, Ludhiana, Gurdaspur, Karnal, Pantnagar and Hissar
Loose smut	Ludhiana, Karnal, Hissar, Delhi, Almora and Pantnagar
Flag smut	Hissar, Durgapura and Ludhiana
Hill Bunt	Palampur and Almora
Head Scab	Karnal, Gurdaspur and Dhaulakuan
Leaf blight	Ludhiana, Karnal, Faizabad,Varanasi,Kalyani,Pusa(Bihar) and wellington
Powdery Mildew	Almora, Simla, Palampur, Ranichauri, Pantnagar, Dhaulakuan, Wellington and Kaul
Foot rot	Dharwad and Sagar

(Ref. DWR,karnal)

Rusts: For the management of Rusts, Crop health surveillance , apart from providing decision making tool for taking up the plant protection measures, also provides information on the occurance and spread of the disease in a locality and on the specific cultivar(s) with the pathotypes emerged. Based on different modules formulated and validated at farmers' fields, the following package are recommended for management of rusts particularly yellow rust in Northern India:

- Use of high yielding diseases resistant Wheat varieties; Stripe rust resistant varieties are HD2967, WH1105, HD3086, DBW88,DBW71, HD3059, WH1021, WH1080, HD3043, DBW90, HS507,HPW349 and HS 542.

- Timely sowing in Zerotill or well prepared field with pplication of recommended doses of fertilizes;

- Application of 0.1% solution of Tilt (Propiconazole 25EC) or Tebuconazole 250EC @ 500 ml/ha immediately after the appearance of any of the diseases i.e. Rust/foliar blight and powdery mildew. The spray should be at 15-20 days interval. Prophylactic spray in the adjacent areas should also be done.

Karnal Bunt : The disease caused by Tilletia indica, a basidiomyceteous fungal disease was first reported from Karnal in Haryana in 1931.Karnal Bunt disease perpetuate year after year through seeds, soil and air borne inoculums. Integrated management approach is the ideal measure to manage the disease. Under cultural approach, crop rotation, fallowing the land, non cultivation of wheat for more than 3 years which may extend till 7 years , adequate irrigation and balanced fertilizer application besides seed treatment with with Carboxin or Carbendazim @ 1.25 g/Kg of seed and Tricoderma harzianum @ 2 g/ Kg of seed may be adopted. Spraying Propiconazole at heading stage, although does not eradicate the disease but induces more than 71% control of Karnal Bunt. Some biocontrol agents like *Trichoderma viride, T.harzianum, T. lingorum, Gliocladium deliquscens etc.* may control the disease. Growing resistant varieties is the most effective way in managing the disease. Over the years , number of KB resistant varieties have been developed and released for cultivation . Prominent KB resistant varieties recommended for cultivation in various zones are:

- **For NHZ**: HS 420(2003), VL829(2002), VL892(2007), HS375(2003).
- **For NWPZ**: PBW527(2004), PDW314-d(2010), HD2687(1999), PBW 590(2008), HD2967(2009), DPW-621-50 (2011).
- **For NEPZ**: NW1012(1997), NW 2036(2003), K 9006(1998),K 8434 (2001), Halna (2001), K 9533(2002), HD 2643 (1997), HP 1744(1997), NW 1014(1998), HI 1563 (1999), PBW343(2000)
- **For central Zone(CZ)** : HI8381(1995), HI 8737 d(2014), DBW110(2014), PBW524(2004), Raj 3765(1996).
- **For peninsular Zone(PZ)**: UAS 428(2012).

Loose Smut: The disease caused by Ustilago tritici is one of the major diseases of wheat that occur in the NWPZ states. Treatment of seeds with systemic fungicide viz., Carboxin or Carbendazim(Bavistin) @ 1.25 g/Kg of seed and Tricoderma harzianum @ 2 g/ Kg of seed manages the disease.

Insect-Pests incidence: Wheat crop in India is relatively free from epidemics of insect-pests. However, incidence of Shoot fly, Brown wheat mite and Aphids are not uncommon. Termites have been a problem in some areas which can be controlled by seed treatment with Chlorophyriphos 20 EC @ 4 ml/Kg of seed in Termite infested area.

The IPM approach would help in reduction in cost of production, more economic access of food to the poor and conservation of the resilience and integrity of ecosystems.

10: Harvesting, threshing and storage

Fields should be total dry and harvesting should be done when the ears are sufficiently dry and the grain moisture content is around 14 to 20%. The harvested crop is thereafter threshed and sundried to a moisture level of around 10-12% for safe storage. Grains should be in galvanized beans and fumigate it with aluminum phosphide @ 01 tablet (3g of each) or EDB @ 3 ml/100 kg of grains. The crop is harvested in different periods in various zones/states. The zonewise harvesting period of wheat and threshing techniques adopted are as under:

Wheat growing Zone	Harvesting period	Method of harvesting and threshing
NWPZ	Mid April to April end	Mechanized harvesting through Combined harvester on custom hiring basis in most cases; also by reaper binder and threshing by mechanical threshers in some areas.
NEPZ	Last week of March to April	Generally manual harvesting; however, use of combines are observed in vast areas of wheat in West Bengal. Reaper binders are also being introduced. Mechanical threshers are used.
Central Zone (CZ)	End of February to March	Mostly manual harvesting. Mechanical threshers are used.
Peninsular Zone (PZ)	Later February till end of February	Mostly manual harvesting. Mechanical threshers are used.
Northern Hill Zone(NHZ)	May-June	Mostly manual harvesting. Mechanical threshers are used.
Southern Hill Zone (SHZ)	February	Mostly manual harvesting. Indigenous manual threshing is in practice.