Current concepts for estrus synchronization in bovine

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Abstract

In animal breeding, synchronization has major role to play especially to bring the animals to estrus at a desired time by using exogenous hormones. Over the past years, a number of substances have been introduced to induce estrus in farm animals. Ovulation may be synchronized with progestins and estrogen combination treatment, a 2-dose prostaglandins (PG) regimen, or a GnRH and PG combination. Progesterone may be considered as a drug of choice, because it is easily applied at low cost. Melengestrol Acetate (MGA), Progesterone Release Intra-vaginal Device (PRID) and Controlled Internal Drug Release devices (CIDR) are progestins approved for use in cows. The five systems for fixed-time insemination with GnRH-PG combinations are Ovsynch, Cosynch, Select Synch, Hybrid Synch and Heatsynch. Hybrid Synch has a lower cost and less handling compared with Ovsynch and CO-Synch but more than Select-Synch. The use of Estradiol cypionate within the Ovsynch protocol may offer dairy producers an alternative. In sub Saharan Africa, the educational level of the farmers, the potential of the available resources (cultivated or natural pastures, rain distribution, water availability, ecological environment, etc.) and the cost of the technology are factors that explain partially why the use of modern reproductive techniques (estrus synchronization and artificial insemination) are not applied on a commercial scale.

Keywords: Bovine, fertility, GnRH, estrus, progestins, prostaglandins

Concepts actuels pour la synchronisation de l'oestrus chez les bovins

Résumé

En reproduction animale, la synchronisation joue un rôle majeur en provoquant l'œstrus d'animaux à un moment souhaité en utilisant des hormones exogènes. Au cours des dernières années, un certain nombre de substances ont été introduites pour induire l'œstrus chez les animaux d'élevage. L'ovulation peut être synchronisée avec des progestatifs et un traitement par association d'œstrogènes, un régime de 2 doses de prostaglandines (PG), ou une combinaison de GnRH et de PG. La progestérone peut être considérée comme un produit de choix, car elle est facilement appliquée à faible coût. L'acétate de melengestrol (MGA) et les dispositifs PRID et CIDR sont les progestatifs approuvés pour l'usage chez les vaches. Les cinq systèmes d'insémination à temps fixe avec la combinaison GnRH-PG sont Ovsynch, Cosynch, Select Synch, Hybrid Synch et Heatsynch. Hybrid Synch est moins coûteux et facile à manipuler par rapport à Ovsynch et Co-Synch mais plus que Select-Synch. L'utilisation du cypionate d'Estradiol dans le cadre du protocole Ovsynch peut offrir une alternative aux producteurs laitiers. En Afrique subsaharienne, le niveau d'éducation des éleveurs, le faible potentiel des ressources disponibles (pâturages cultivés ou naturels, répartition des pluies, disponibilité de l'eau, environnement écologique, etc.) et le coût de la technologie sont des facteurs expliquant en partie pourquoi l'utilisation des techniques modernes de reproduction (synchronisation de l'œstrus, insémination artificielle…) ne sont pas appliquées à l'échelle commerciale.

Mots clés: Bovins, fertilité, GnRH, oestrus, progestagènes, prostaglandines

INTRODUCTION

Reliable methods for the artificial regulation of the estrus cycle have long been sought for the purpose of increasing productivity and decreasing costs in food-producing animals (Looney et *al*., 2005). The widespread application of artificial insemination to bovine has prompted interest in developing methods for the artificial regulation of estrus cycles in order to inseminate maximum number of animals on a single day (Baruselli et *al.,* 2007). Methods that were first developed often resulted in an acceptable synchronization of estrus. In oestrus synchronization the manipulation of the bovine oestrus cycle results in standing oestrus in majority of animals, within a short period of time (Islam, 2011). If the oestrus synchronization protocol needs to be successful then it requires to synchronize the follicular waves and/or luteal regression (Vikrama Chakravarthi and Sri Balaji, 2010). Techniques are now available to predictably alter the time of estrus within the breeding season (estrus synchronization) and to induce estrus during periods of anoestrus (estrus induction), while maintaining a high level of fertility. Protocols differ in hormones used, method of hormone administration (injection, vaginal insert, or consumption through feed), number of injections, number of times cattle or buffaloes must be handled, timing of injections, and heat detection requirements. Three basic approaches are used for synchronization of estrus in bovine classified to pharmacological methods by the use of progestins (MGA, MAP, FGA, PRID et CIDR-B) to keep animals out of heat and extend the estrus cycle, prostaglandins (PG) to bring females into heat and shorten the estrus cycle, and GnRH to cause ovulation or start development of a new follicular wave (Kharche et *al.,* 2010).

ESTRUS SYNCHRONIZATION BY USING PROGESTINS

One of the first methods used to synchronize oestrus in cattle was the long-term feeding of melengestrol acetate (MGA; Zimbelman and Smith 1966). MGA is a synthetic progestin that suppresses estrus when fed at the rate of

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0.5 mg/head/day. MGA is still used extensively today by feedlots to suppress estrus in beef heifers that are being fed for harvest and used for estrus synchronization of heifers with a 14 day feeding program followed by a single injection of $PGF_2\alpha$ 17 day after withdrawal of MGA feeding.

It is well established that administration of exogenous progesterone can hasten the attainment of puberty in heifers and cause cyclicity in postpartum anoestrus cows. The ability of exogenous progestin to induce oestrus in anoestrus cattle has been attributed to, in part, increased LH secretion both during and after treatment. It has been reported that progestin treatment increased LH secretion in postpartum beef (Garcia-Winder et *al.,* 1986) as well as seasonal dairy cows (Rhodes et *al.,* 2002). In addition, LH secretion following weaning was increased in cows with prior exposure to progestin (Breuel et *al.,* 1993). This induced increase in LH is important because it mimics the pro oestrus increase in LH leading to the preovulatory LH surge (Day, 2004).

Recently, CIDRs was admitted to control oestrus in cattle in USA. A controlled internal drug-releasing device (CIDR®) is inserted into the vagina of the female and releases into the blood stream a product with progesterone-like activity. The device is removed seven days later and the resulting decline in blood progesterone allows cycling cows and heifers to have oestrus together. A prostaglandin injection is given at day six or day seven to regress any currently active corpora lutea that may still exist. Researchers have reported that CIDRs could help stimulate oestrus activity in prepubertal heifers and in some anoestrus cows (Islam, 2011).

In buffaloes, intravaginal devices impregnated with progesterone (PRIDs and CIDRs) and ear implants impregnated with a potent progestagen (norgestomet) have been widely used (Hattab et *al.,* 2000). In dealing with anoestrus animals, gonadotrophin (usually PMSG) has often been administered at the time of progesterone/progestagen withdrawal. For oestrus synchronization and oestrus detection in swamp buffaloes, Hill et *al*., (1992) observed that although CIDRs can be used in buffaloes, there can be a high rate of loss.

ESTRUS SYNCHRONIZATION BY USING PROSTAGLANDINS INJECTION

The luteal phase is characterized by the functioning corpus luteum (CL) secreting progesterone. During the late luteal phase (day 16 - 18 of the cycle), $PGF_2\alpha$ is released from the uterus and binds to the CL causing luteal regression. During the 1970s, it was discovered that $PGF_2\alpha$ was luteolytic in cattle and could be used to synchronize oestrus (Lauderdale et *al.,* 1974). It was later determined that $PGF_2\alpha$ had limited utility in synchronizing oestrus because it was only effective in cattle that were cycling and had a CL (day 5 to 17 of the cycle). Therefore, prepubertal heifers, anoestrous females, females on d 0 to 4 of the oestrous cycle, and females in the final days of the oestrous cycle subsequent to luteolysis were not responsive. It was later determined that the interval from treatment with $PGF_2\alpha$ to oestrus was dependent upon the stage of the follicular wave at treatment (Lucy *et al.,* 1992). Larger, more mature follicles ovulated sooner than their smaller, less mature counterparts. The strategy that is commonly utilized involves two injections of $PGF_2\alpha$ administered 11 to 14 days apart (Cooper, 1974). No oestrus detection or breeding is done after the first injection, and all heifers, regardless of whether or not they responded to the first treatment are given the second injection. The 75% of cycling heifers that should respond to the first injection within 96 hours are on days 6 to 14 of the oestrous cycle at the time of the second injection. The 25% of cycling heifers that are not expected to respond to the first injection because they have "young CLs" (<5 days post ovulation) are on days 10 to 19 of the oestrous cycle at the second injection. Therefore, by utilizing two injections, 100% of the heifers should be at a stage of the oestrous cycle that will allow them to respond to the second $PGF_2\alpha$ injection. Observation of heifers for indications of oestrus behavior followed by artificial insemination 12 hours after first detection follows the second PGF2α treatment for at least 96 hours. The advantage of this system is that only 4 days are required for oestrus detection and AI. The disadvantage is the increased cost, labor, and management that results from the fact that all the heifers are handled twice for $PGF_2\alpha$ treatments, as well as being handled once for insemination. And, although sound theoretically, the effectiveness of synchronization and pregnancy percentages are not always acceptable following this method (Dutt and Kharche, 2000; Kharche and Srivastava, 2001; Kharche and Srivastava, 2002; Kharche and Srivastava, 2005). However, synchronization and pregnancy percentages are improved when the injections are given 14 days apart rather than on an 11 day interval (Folman et *al*., 1990).

Some authors suggested the combination of progestins and prostaglandins to increase the results. Prostaglandin has also been used as a co-treatment in effective progestogen-based synchronization protocols in cattle (Lucy *et al.,* 2001; Islam, 2011) for both natural mating and AI/timed AI situations. Tada et *al.,* (2010) reported 85% and 67% in oestrus response respectively in dairy and beef cattle with prostaglandin and progesterone analogues. Prosolvin, a prostaglandin analogue, produced a higher (87%) oestrus response than Crestar implant (67%), a progesterone analogue. Silent oestrus was higher in Crestar treated cows than Prosolvin treated cows. Similar findings on application of "Crestar" for induction of oestrus in heifers has been reported by Deka et *al.,* (2009).

In Senegal, within the framework of the AI national program, we applied the following protocol in Gobra zebu: sponge PRID® containing 1.55g of progesterone and 10 mg of estradiol benzoate (Progesterone Release Intravaginal Device "*Ceva santé animale*") from day 0 to day 12; intra muscular (i.m.) injection of 25 mg $PGF_2\alpha$ at day 10; PRID® removal and i.m. injection of 500 I.U. PMSG at day 12; insemination at day 14 after oestrus detection (If the zebu stands still, she was definitely in heat). We obtained a synchronization rate and a conception rate of 99.3 % and 47,0% respectively (Kouamo et *al.,* 2010; Kouamo et *al.,* 2011; Kouamo *et al.,* 2014). High levels of reproductive performance can only be achieved under optimum management conditions (including nutrition).

This is one factor that determines the dramatic differences in reproductive efficiency between the developed and the developing countries (where the nutrition and general management of the flocks are not quite good). In developing countries, particularly in Sub Saharan Africa, most of the cattle populations are maintained with more or less intensive systems of production or in the hands of communities with very poor levels of education. The structural aspects of land (pasture or natural resources) distribution are important factors that determine the possibility of using different systems of production and technology in the small ruminant production. This coupled with the educational level of the farmers and the potential of the available resources (cultivated or natural pastures, rain distribution, water availability, ecological environment, etc.) finally decides which practices or technologies can be applied economically to improve the productivity (Kouamo et *al.,* 2009a). In addition the "cost of the technology" is an additional factor that has to be considered and can explain partially why in developing countries the use of modern reproductive techniques that are in practice in developed countries (e.g. controlled breeding) are not applied on a commercial scale. Kouamo et *al*., (2009b) reported that the cost of artificial insemination (first service) after synchronization by hormones in Senegal was 33797 FCFA ($68 US).

Prasas et *al.,* (1981) reported that prostaglandins treatments reduce the concentration of protein and activities of acid and alkaline phosphates and peroxidase in cervical mucus of buffalos after induction of oestrus. These changes in some biochemical constituents of the cervical mucus could alter the passage of spermatozoa.

It is generally thought that both oestrus response and fertility rates obtained in buffalo cows are lower than in cattle after the treatment with prostaglandins (kharche and Srivastava, 2001). The most probable reasons for these differences are low poor body condition encountered often in post partum buffalo cows affecting the follicular growth and low oestrus detection efficacy in these species. El-Belely et *al.,* (1995) observed 77% overall oestrus rate after two $PGF_2\alpha$ treatments but only 25% of the buffalo responded to the first treatment, and Phadnis et *al.,* (1994) observed a 55.7% oestrus rate after two treatments.

In spite of these limitations, oestrus management with prostaglandins should be recognised as the most readily available and also valuable tool facilitating artificial insemination and allowing for an improved reproduction efficacy in cattle and buffalo herds. In search for the possibilities for cost reduction of the treatments involved in the reproduction management in buffaloes, intravulvo-submucosal injection of prostaglandins has been tested by various researchers and practitioners (Dutt and Kharche, 2000; Kharche and Srivastava, 2001; Kharche and Srivastava, 2002; Kharche and Srivastava, 2005). This route of administration reportedly allows for a reduction of the dose of $PGF_2\alpha$ used by 50%.

ESTRUS SYNCHRONIZATION BY USING GNRH

Single injection of GnRH at standing oestrus increased the pregnancy rate with increasing the dose of GnRH (Srivastava and Kharche, 2002; Kharche and Srivastava, 2007). The most recently developed synchronization treatments combine traditional methods of controlling cycle length with the manipulation of follicular development in order to "program" or "select" the ovulatory follicle (Islam, 2011). The five systems for synchronization of estrus with GnRH-PG combinations are Ovsynch, Select Synch, Hybrid Synch, Cosynch and Heatsynch.

The Ovsynch program is comprised of an injection of GnRH on day 1, an injection of prostaglandin on day 8, a second injection of GnRH on day 10 and then timed insemination on day 11 (Pursley *et al.,* 1995a; Pursley *et al*., 1997a,b; Pursley *et al.,* 2001). Pursley *et al.,* (1995b) indicated that pregnancy rates varied when cows were timed inseminated at 0, 8, 16, 24 or 32 h after the second injection of GnRH in the Ovsynch program and the highest pregnancy rate (45%) was achieved when insemination was done 16 h after the second GnRH injection. The stage of the oestrus cycle when Ovsynch was initiated also affect synchronization and conception rate (Vascon-celos *et al.,* 1999). Pre-synchronization strategies are being developed to optimize stage of the cycle at Ovsynch initiation and improve success with fixed time AI (FTAI), particularly in anovular cows (Gümen *et al*., 2003). Ovsynch produces ovulation at second GnRH treatment in both ovular and anovular cows; although, size of the ovulatory follicle and hormone levels are variable and not optimized.

To improve pre-synchronization, a Double-Ovsynch protocol was developed, using Ovsynch for pre-synchronization followed 7 day later by a normal Ovsynch 56-FTAI protocol (Sartori *et al.,* 2009). In one study using 337 Holstein cows, the use of Ovsynch for pre-synchronization instead of two injections of $PGF_2\alpha$ 14 day apart improved CR in primiparous (65 vs 45%), but not multiparous (38 vs 39%) cows (Souza *et al.,* 2008). In another study with 514 cows, a Double-Ovsynch protocol with high progesterone (GnRH-7days-$PGF_2\alpha$-3days-GnRH-7days-GnRH-7days-$PGF_2\alpha$-56h-GnRH-16h-AI) improved conception rate as compared with a low progesterone protocol (GnRH-7days-$PGF_2\alpha$-3days-GnRH-7days-$PGF_2\alpha$-56h-GnRH-16h-AI), independent of parity (48 vs 33%; Cunha et *al*., 2008). In Buffalo, Ovsynch treatment has resulted in acceptable pregnancy rates after FTAI in cycling buffalo during the breeding season (Berber et *al*., 2002; Paul and Prakash, 2005). FTAI protocols using progestin devices, oestradiol and eCG have resulted in synchronous onset of a new follicular wave, synchronous ovulation and consistent pregnancy rates in anoestrus buffalo during the off breeding season (Baruselli et *al.,* 2003).

The combination of these protocols permits the use of AI throughout the year, obtaining conception and calving even in anoestrus buffalo during the off breeding season. Borghese (2005) stated that administration of prostaglandin alone or in combination with GnRH increased the conception rate (CR) up to 56%. Yendraliza et *al.,*

(2011) reported that treatment of buffalo-cows in different postpartum periods with 3ml GnRH at day 0, followed by 2.5ml $PGF_2\alpha$ 7 days later improved their reproductive efficiency. Conception rate obtained in their study with Ovsynch protocol followed by artificial insemination in buffalo-cows is considered high when compared to other similar experiments observed by several workers such as Mialot et *al.,* (1999) and Baruselli et *al.,* (1999). They concluded that the protocol is effective to resume ovarian activities as early as 30 days postpartum, and appears to be a useful oestrus synchronization method as well in improving the reproductive performance of Kampar swamp buffalo-cows.

El-Wishy (2007) reported that the sequential administration of GnRH and $PGF_2\alpha$ was suggested for management of postpartum reproductive activity in problem herds. De Rensis and Lopez-Gatius (2007) revealed that GnRH can be administered at day 14 postpartum followed by $PGF_2\alpha$ 14 days later. They suggested that the logical basis for this treatment regimen was that GnRH treatment would enhance ovulation and subsequent $PGF_2\alpha$ treatment would induce luteolysis of CL then ovulation. Administration of $PGF_2\alpha$ at 7-10 days postpartum was effective in facilitating the uterine involution and resumption of ovarian cyclicity and improving reproductive performance (Noakes et *al*., 2001).

Higher conception rate was reported in suboestrus buffaloes initiating the treatment with Ovsynch during the later stages of oestrous cycle, but conception rate was 0 in anoestrus buffaloes though incidence of cyclicity was observed due to the treatment (Ravikumar and Asokan, 2008). The efficiency of different ovulation inducers in Buffalo (hCG or GnRH) on follicular dynamics (Carvalho et *al.,* 2005) and conception rate were studied. GnRH is cheaper than hCG and it would reduce the cost of the synchronization protocol. No difference was found in the follicular responses and ovulation between treatments. Buffaloes treated with GnRH and hCG presented similar ovulation rate [76.5% (13/17) vs 81.3% (13/16)] and interval between device removal and ovulation [74.8 ± 3.6h vs 72.9 ± 3.7h]. Therefore, similar conception rate was found between hCG (52.3%; 68/130) and GnRH (51.8%; 58/112; $P>0.05$). Results indicate that the use of GnRH instead of hCG provided satisfactory conception rate in buffalo during the off breeding season and it might reduce the cost of the protocol for fixed time artificial insemination (Baruselli et *al.,* 2007).

With the Select Synch system, cows are injected with GnRH and $PGF_2\alpha$ 7 days apart (Geary et *al*., 2000). Heat detection begins 24-48 hours before the $PGF_2\alpha$ injection and continues for the next 5-7 days. The $PGF_2\alpha$ injection is excluded for cows detected in oestrus on day 6 or 7. Animals are inseminated 8 to 12 hours after observed in standing oestrus. Alternatively, heats detect and A.I. until 48 to 60 hours after $PGF_2\alpha$ and then mass-AI the rest of the herd at 72 hours and give GnRH to those cows that have not exhibited oestrus. It is currently recommended that for Select Synch-treated cows, detection of estrus begin as early as 4d after GnRH injection and continue through 6d after PG (Kojima *et al*., 2000). Major benefits of the Select Synch system are simplicity and tighter synchrony of oestrus. Most animals will display standing oestrus 2 to 4 days after the $PGF_2\alpha$ injection. Overall, oestrus response rates in well-managed beef herds average 70 to 75% with no adverse effect on conception rates (60 to 70%), resulting in synchronized pregnancy rates that average between 45 and 50% (Islam, 2011).

The Hybrid Synch program is implemented with an injection of GnRH on day 1, an injection of prostaglandin on day 8 and then estrus detection and breeding from day 8 to 11. Females not observed in estrus from day 8 to 11 are bred on day 11 and given a second injection of GnRH (Islam, 2011). This program has a lower cost and less handling compared with Ovsynch and Cosynch but more than Select-Synch. The primary advantage is that Hybrid-Synch appears to have the highest conception rates among all GnRH-prostaglandin programs.

The Cosynch program is comprised of an injection of GnRH on day 1, an injection of prostaglandin on day 8 and then a second injection of GnRH with breeding on day 10. The advantages are tight synchronization of oestrus, most females respond to the program and it encourages oestrus in non-cycling cows that are at least 30 days postpartum. However, of the estrus or ovulation synchronization protocols currently used for suckled beef cows, CO-Synch tends to be more cost effective and less labor intensive than other timed-AI synchronization protocols (Kojima *et al*., 2000; Geary *et al*., 2001). A disadvantage of this protocol is that approximately 10 to 20% of suckled beef cows exhibit estrus prior to and immediately after the PGF2α injection. Unless these cows are detected in estrus and inseminated, they will fail to become pregnant after the CO-Synch protocol (Lamb et *al*., 2001).

With the heatsynch, Estradiol cypionate (ECP) replace the second GnRH injection in TAI to successfully induce ovulation, when administered 24 h after the injection of PG. Since it was determined that dairy heifers and non-lactating dairy cows ovulated 62 and 60 h after ECP injection, respectively, artificial insemination was scheduled 48 h after ECP injection. One of the uses of exogenous estradiol as part of estrus synchronization systems is based on estradiol's ability to induce LH surge by stimulating hypothalamic secretion of GnRH. Estradiol also increases pituitary sensitivity to GnRH, apparently by increasing the number of GnRH receptors within the pituitary. The use of ECP within the Ovsynch protocol may offer dairy producers an alternative, cost efficient reproductive management system if effective in lactating dairy cows. Ahmadzadeh et *al.,* (2003) observed that 0.25mg of estradiol cypionate given with the final GnRH of the Ovsynch tended to increase conception rates in beef cows (68% versus 57.5%; $P = 0.14$). Furthermore, inducing ovulation with 1 mg of estradiol cypionate in the Heatsynch protocol increased conception rate compared to cows inseminated at estrus (Cerri et *al*., 2003).

Another synchronization system that is a combination of two other protocols is called the "7 – 11 Synch" program. This is a combination of feeding MGA® and injecting GnRH and prostaglandin (Hixon *et al*., 2001). The MGA is fed for seven days, prostaglandin injected on the last day of MGA feeding, and the "Select Synch" protocol is initiated four days later (Patterson et *al*., 1999). The timed AI could be employed at about 60 hours after the prostaglandin injection. The insemination could also be accompanied by another injection of GnRH. Synchrony of estrus after PGF2α in an MGA system tends to be tighter with more heifers being artificially inseminated during a shorter period of time than when using a GnRH protocol (Funston *et al*., 2002). Nonetheless, fertility in heifers that are estrus detected and inseminated after a detected estrus does not appear to be compromised over a normal 2 × PGF2α system, whereas heifers inseminated after a fixed time with or without an additional injection of GnRH before the CO-Synch protocol appears to have improved fertility over a 2 × PGF2α system, especially in heifers with poorly developed reproductive tracts (Lamb *et al*., 2001).

More recently, researchers combined the Cosynch method with a CIDR®. The number of trips through the working chute is no different than was already planned for the Co-Synch method. The CIDR® is in place during the seven days between the first GnRH injection and the prostaglandin injection. Timed AI can be performed with this protocol. Richardson *et al.,* (2002) reported a higher and tighter oestrus response (ER) and higher conception rate, in dairy and beef heifers combined, when GnRH was given or not given at day 1 of a 7 day CIDR® insertion protocol with prostaglandins on day 6 (ER = 84.1 et 87.1 %; Conception rate = 58.2 et 58.6 %) vs a Select Synch protocol (ER = 77.7 %; Pregnancy rate (PR) = 53 %). By moving the PG injection from day 6 to day 7 (at CIDR® removal). Lamb *et al.,* (2001) showed that pregnancy rates were higher in suckled beef cows that received a CIDR® + Cosynch protocol (58 %) vs a Cosynch protocol (48 %) alone. Oestrus response and pregnancy rates in beef heifers were higher in a modified CIDR® + Co-Synch protocol (using GnRH with PG given at day 7; ER = 65.0 % and PR = 65.0 %) vs a 6 d MGA feeding on top of a Co-Synch protocol using GnRH (ER = 35.6 % and PR = 52.5 %) with peak oestrus response for both MGA and CIDR® groups ranging from 36 to 48 h post CIDR® removal (Martinez *et al.,* 2002). If oestrus response is highest within 36 – 48 h post CIDR® removal, possibly due to incorporation of GnRH at CIDR® insertion and PG can be given at CIDR® removal, then delaying timed-insemination may also result in higher pregnancy rates (Zalesky and Walker, 2003). A shortened 5-day Cosynch + CIDR® protocol is another option for cows. Two full doses of PG given 8 hours apart are critical for success in the shortened protocol (Johnson et *al.,* 2011).

CONCLUSION

Research has increased the number of synchronization options. A producer has many choices to pick from to tailor a synchronization protocol to his operation, his production goals and his available labor. However, estrus synchronization programs must be inexpensive, easy to administer and have a high rate of success before producers will adopt them. If proper levels of nutrition, body condition and health are not maintained, the program is likely to fail. Improvements in facilities and management may be necessary before implementing an estrus synchronization program.

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